TECHNOLOGY DEPT

February 1946

TECHNOLOGY REVIEW

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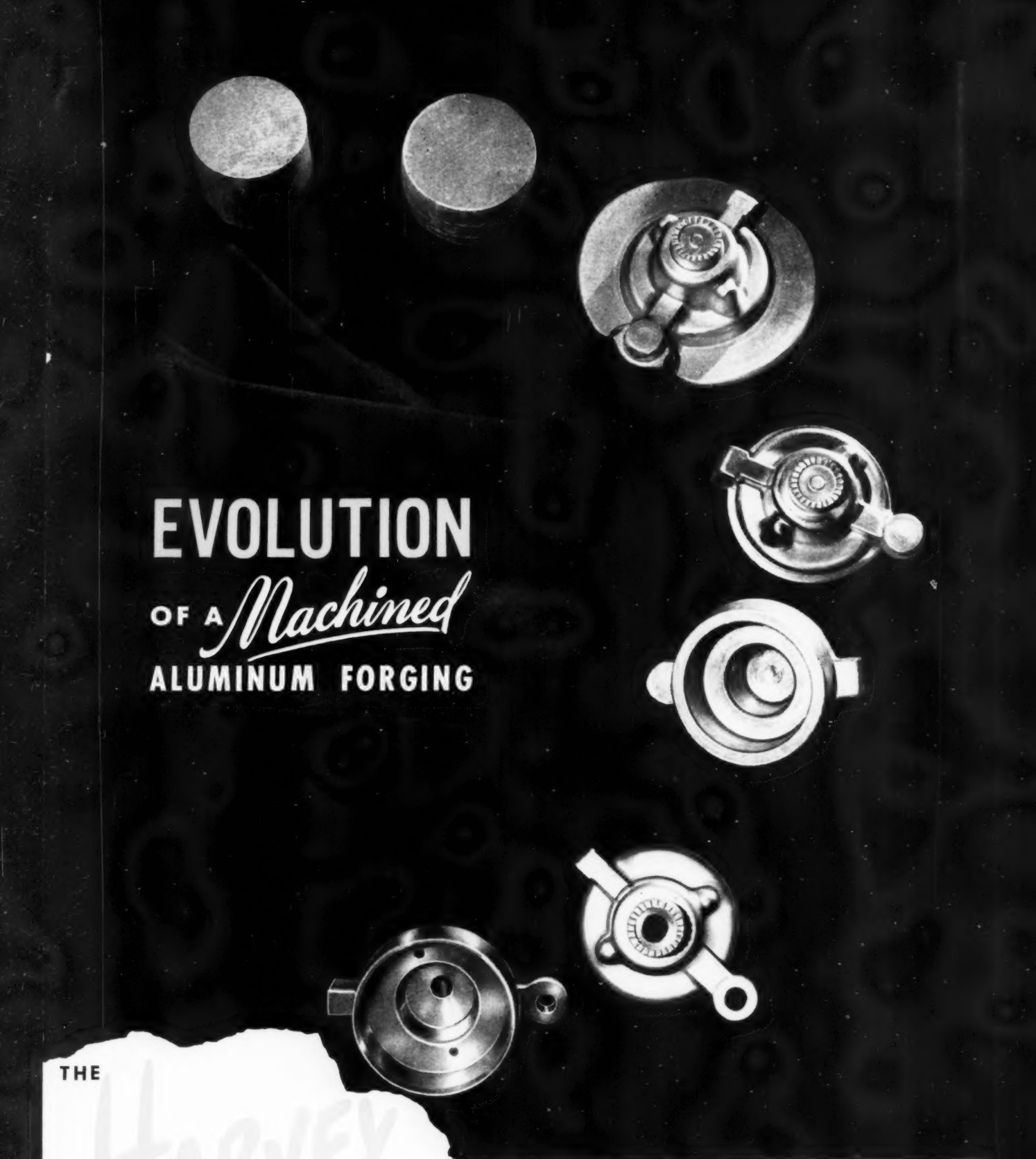

EVOLUTION
OF A *Machined* ALUMINUM FORGING

THE HARVEY

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HAROLD B. HARVEY '05 • *Engineers & Manufacturers* • SHERRY O'BRIEN '17

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FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOYS

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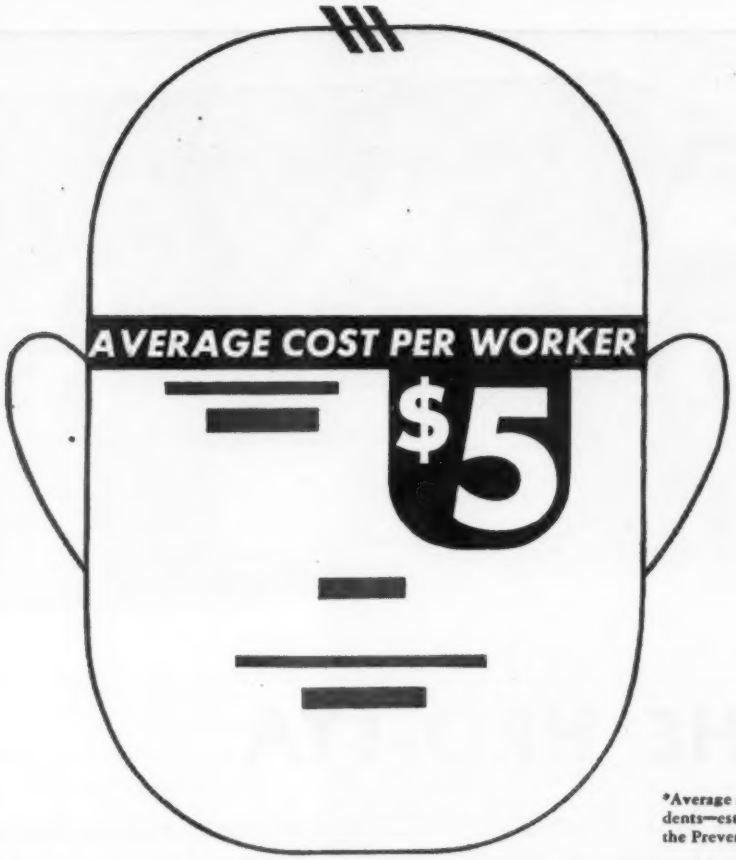

*Average annual cost for all eye accidents—estimated by the Society for the Prevention of Blindness.

It's Cheaper Not to Take Chances

AO SAFETY GOGGLES SAFEGUARD THE EYES OF INDUSTRY

Why let this excessive cost continue when you can equip your workers with *positive* protection—AO Safety Goggles—for about $1.50 a pair. Phone or write your nearest AO Branch Office.

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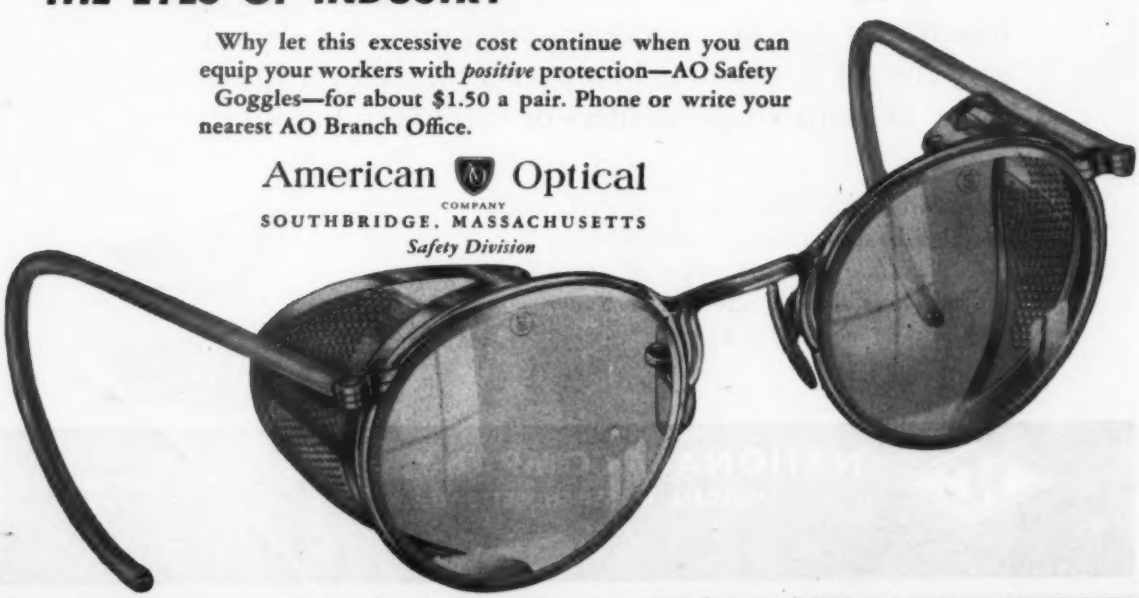

THE TECHNOLOGY REVIEW, February, 1946. Newsstand Edition. Vol. XLVIII, No. 4. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

THE HRO-5TA

Your old friend, the HRO, has seen active service all over the world with the armed forces of the United States and our allies. Much has been learned, and the HRO has emerged from its trial by fire an even better receiver than the superb receiver you knew before the war.

The HRO-5TA (table model) and the HRO-5RA (rack mounting) are new receivers incorporating design improvements based on field reports from all over the world. They are superb performers of extreme reliability.

» *The new National catalogue lists the new HRO-5A receivers and their accessories together with a versatile group of parts you will need in your new rig. Ask your dealer for a copy.*

NATIONAL COMPANY, INC.
MALDEN, MASSACHUSETTS, U.S.A.

MALDEN
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★★★★

Are You Using Cut-off Wheels

that Really Fit Your Jobs?

WHEN a Norton abrasive engineer tackles your cut-off jobs he's not limited to one special type of wheel. He has a *complete line* to choose from — over 50,000 possible specifications. For example, he has several varieties of resinoid bond, both natural and synthetic rubber bond, and shellac bond. He has Alundum, 57 Alundum and Crystolon abrasives. And in each abrasive and bond he has a wide range of grit sizes, grades (hardnesses) and structures.

You can be sure that a survey of your cut-off jobs by a Norton abrasive engineer will really cut costs for you — that among his 50,000 possible specifications there's the low cost wheel for each of your cut-off jobs.

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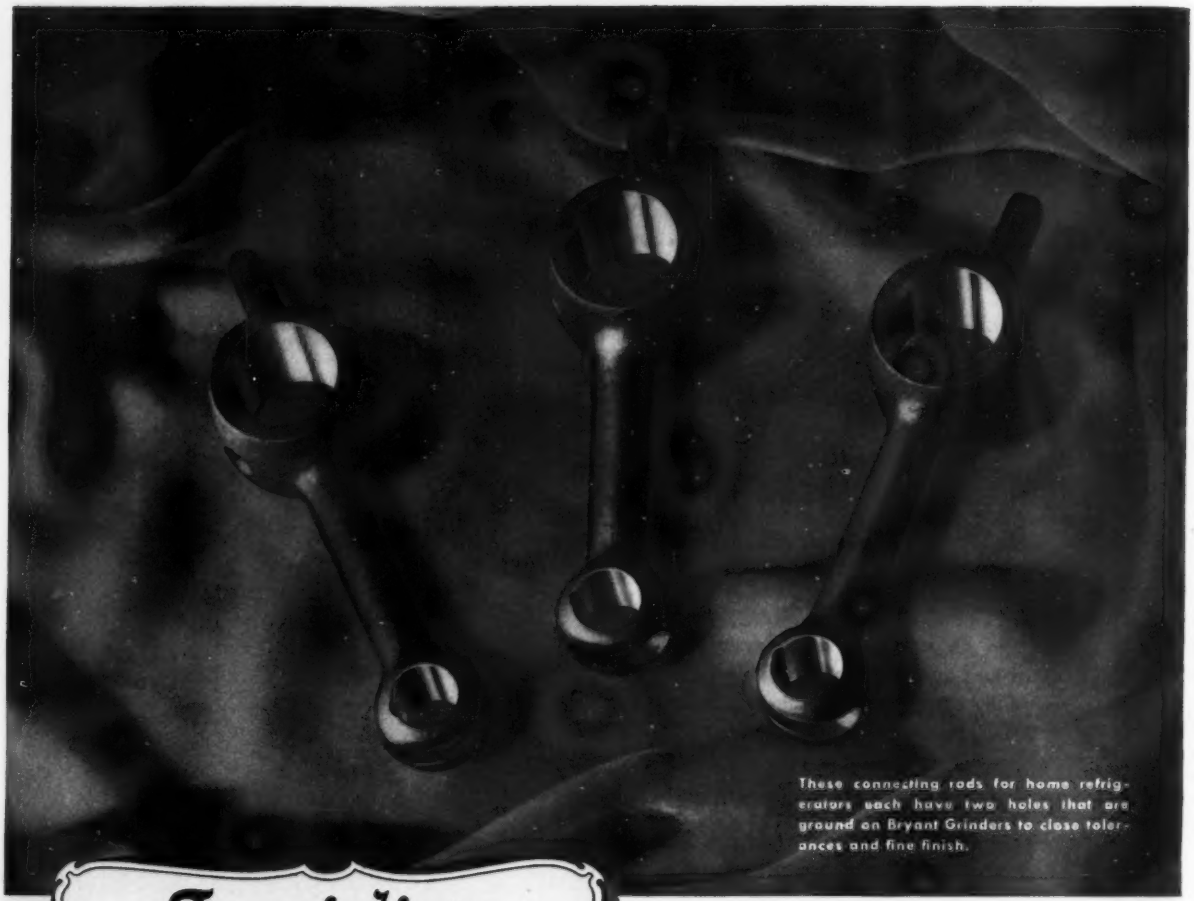

These connecting rods for home refrigerators each have two holes that are ground on Bryant Grinders to close tolerances and fine finish.

Specialists in Forged Steel Jewelry

No, we don't sell it; we don't make it, but we do build internal grinding machines that make it. The three connecting rods for home refrigerators, shown above, are typical examples of the type of work that is ground on Bryant Internal Grinders. They are truly jewel-like in their finish, but that is not enough—to be sure, Bryant Grinders produce metal parts that have surfaces finished correctly to millionths of an inch, when desired, but Bryant machines also produce these same parts with holes that are truly round and straight. These are basic elements that Bryant insists upon to assure Bryant users that their parts and products will last for years without mechanical failure.

WE KNOW YOUR PROBLEM IS DIFFERENT . . .

. . . practically every internal grinding problem is different. But when you require extreme accuracy or high production, or both, your first step should be to study your problem with a man who makes it his business to solve them. Your first step should be to—

Send for the Man from Bryant!

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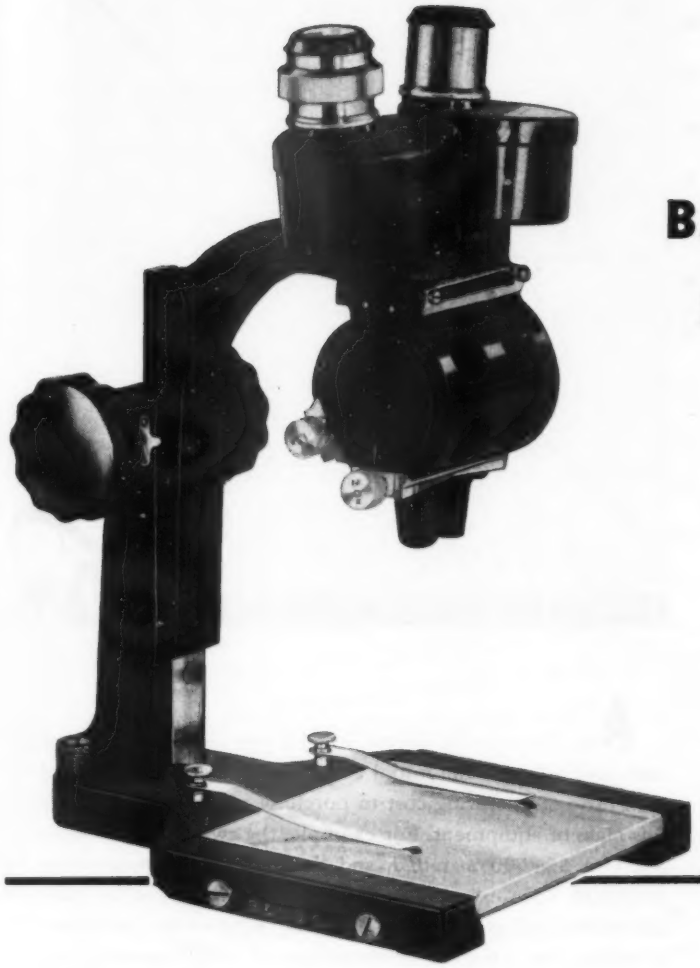
BRYANT CHUCKING GRINDER CO.

SPRINGFIELD, VERMONT, U. S. A.



BAUSCH & LOMB STEREOSCOPIC WIDE FIELD MICROSCOPE

MODEL AKW

THIS is the ideal instrument for dissection, preliminary study, and for examinations that do not require high magnification. The long working distance, the fact that the object is seen as it really is—not inverted or reversed—and the stereoscopic effect, make this instrument invaluable. It may be placed directly upon a gross specimen when desired. Clear glass stage 100 x 100 mm. supplied. Characteristics of this microscope also include an extremely wide field, high eyepoint, and instantly variable magnification with parfocal objectives. Write for Catalog D-15. Bausch & Lomb Optical Co., Rochester 2, New York.

BAUSCH & LOMB

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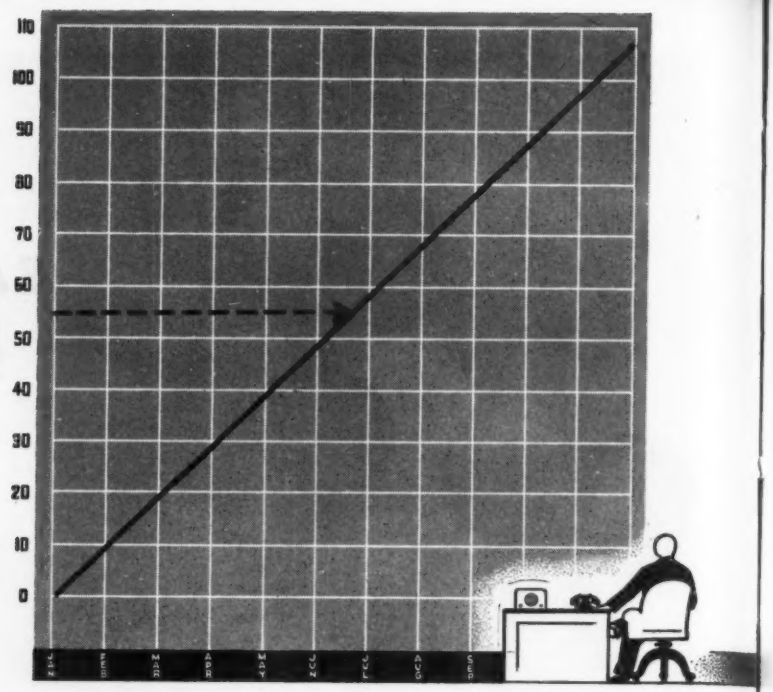
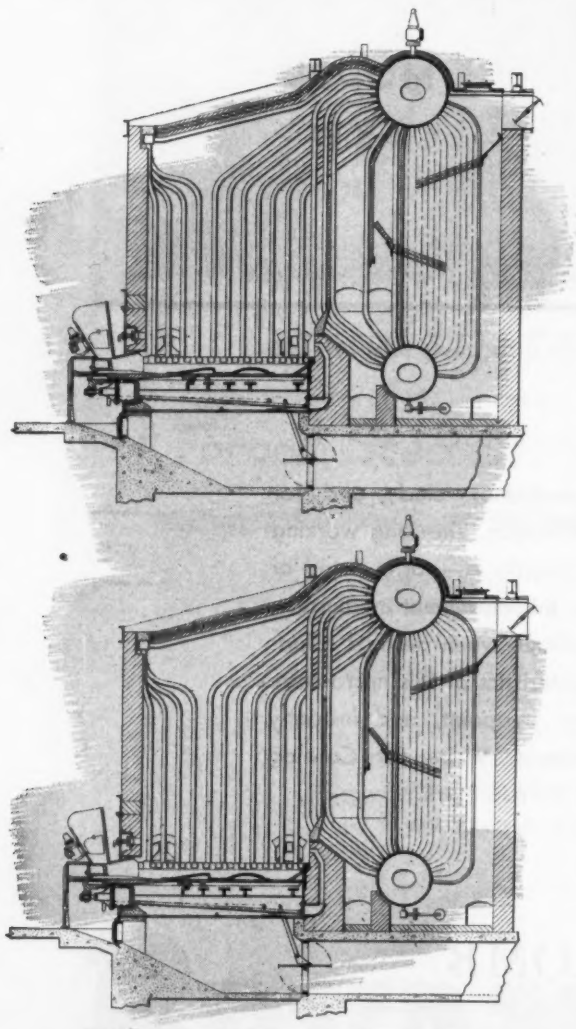
FIRST COST $54,000

ANNUAL FUEL BILL $105,000





Any cost-minded executive who has compared his company's annual fuel bill with the initial cost of his boiler units has discovered the high ratio of operating cost to purchase price which is characteristic of this class of equipment. For example, the two C-E Boilers shown at the left cost $54,000 installed, and the coal they consumed in 1944 cost $105,000. This example is above the average, but in other cases the annual fuel bill will run upwards from 100% of the installation cost. And, of course, this is not the whole picture of boiler operating cost, for labor, routine maintenance, repairs and outage losses total up to quite a substantial yearly figure.

All of which adds up to one simple fact—when it comes to buying boiler units, first cost is decidedly a secondary consideration. The total of annual operating costs is far more important. For obviously a unit that is engineered and built to provide something extra in efficiency of fuel consumption and serviceability will, within the first year of operation, prove to be a far better investment moneywise than a much cheaper unit providing a lower standard of performance. And when the figures are projected over the many years of the useful lifetime of such equipment, the advantage of buying on performance rather than price becomes a matter of simple logic.

Combustion Engineering boilers, fuel burning and related equipment are engineered and built to provide a high standard of lifetime performance. That they do so is attested to by the fact of their widespread use in the plants of leading industrial and utility companies.

Users of C-E equipment have long since discovered that paying for extra values in engineering and construction pays handsome dividends every year.

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C-E

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You name it we'll mold it in RUBBER!

Acct: PRATT & WHITNEY AIRCRAFT DIVISION

Case History #453

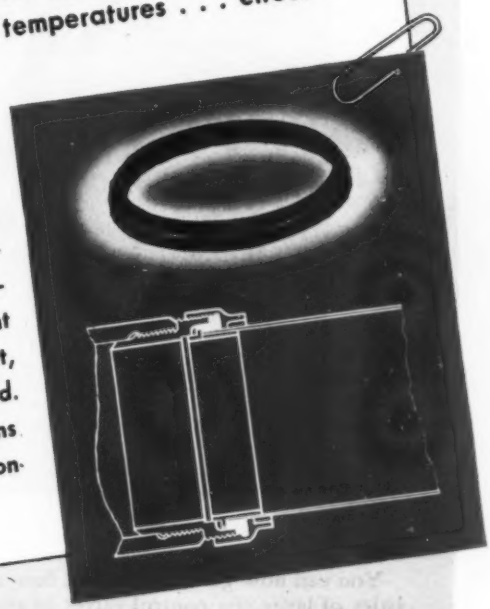
PROBLEM:

To find satisfactory leak-proof packing for ends of Intake Pipe on aircraft engine.

Existing rings permit leakage. Dirty to handle. Skived ends increase assembly cost. Not available in sufficient quantity. Replacement must be highly resistant to gasoline, oil and heat . . . seat to close tolerance . . . maintain dimensional stability under extreme temperatures . . . effect a sustaining perfect, leak-proof union.

SOLUTION:

Developed special design packing, precision-molded from Hycar oil-resistant synthetic rubber. Results of extensive testing under conditions far beyond ordinary demands:—excellent heat resistance, high modulus, good permanent set, perfect performance. Overall assembly cost lowered. Produced in great quantities exact to specifications. All tests proved in actual operation under all conditions. Seal is now a standard part.



The solution to this problem is typical of the hundreds of assembly parts "bugs" we have been privileged to study and overcome for American industry. Perhaps it parallels a problem which confronts you, or suggests a remedy for other product parts difficulties. In either case, Acushnet's accumulated technical experience, engineering skill, unsurpassed laboratory and production facilities (which won five "E" awards during the war) are available for research, recommendations and prompt action. Send complete details of your problem, or requirements for the improvement of your product. We'll gladly make recommendations for the most efficient and economical solution.

Acushnet PROCESS CO.
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Precision-Molded RUBBER Parts & Products

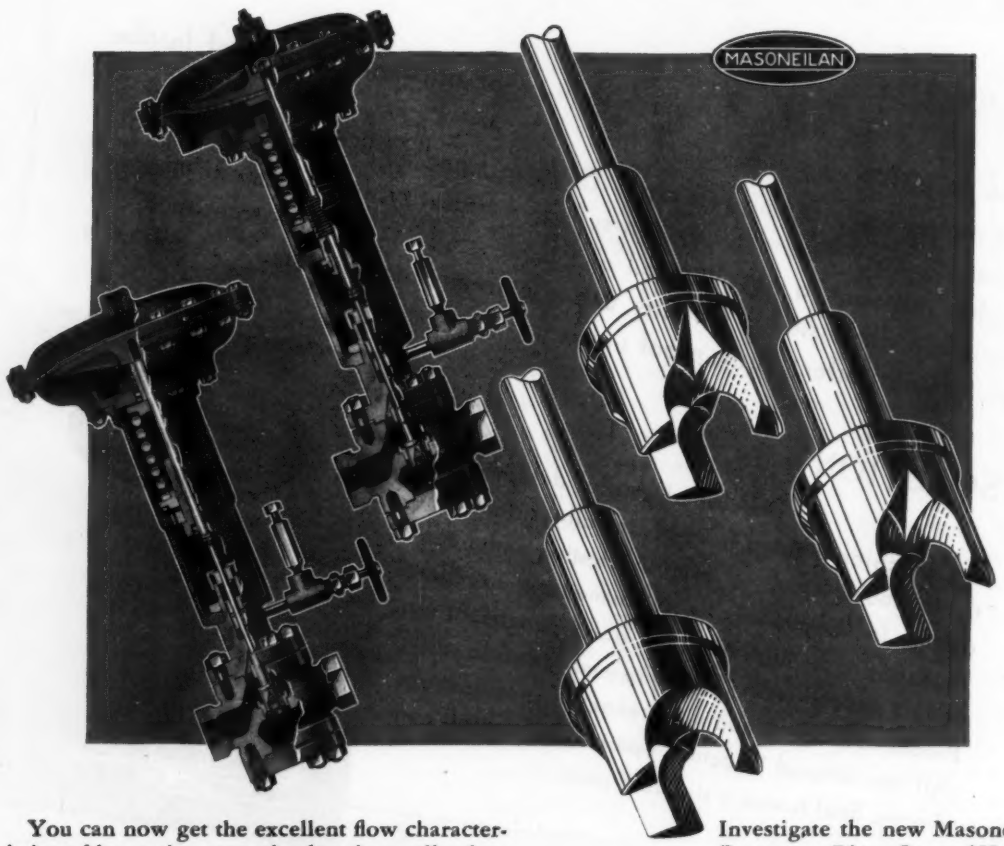
MASONEILAN

Percentage Piston

CONTROL VALVES GIVE YOU FOR THE FIRST TIME

WIDE RANGE PERCENTAGE FLOW CHARACTERISTICS

IN SMALL VALVES



You can now get the excellent flow characteristics of large size control valves in small valves even down to ⅛″ by installing the Masoneilan *Percentage Piston* Control Valves. These new Control Valves . . . which are available in five trim sizes ¾″, ½″, ⅜″, ¼″ and ⅛″ . . . all provide a wide flow range with desirable reproducible characteristics *never before obtained in small valves.* The Masoneilan *Percentage Piston* Control Valves give you consistent performance under conditions of varying flow and pressure drop. When the flow is small, the change in flow for a unit change in lift is small. When the flow is large, the change in flow is large . . . the change *always* proportional to the quantity flowing.

Investigate the new Masoneilan *Percentage Piston* Control Valves. Bulletin 300 gives the complete story. Write for your copy today.

CHECK THESE FEATURES

- Special design of the plug and the seat ring permits excellent flow characteristics over flow ranges of the same magnitudes obtained in larger valves.
- High Lift — All sizes have a ½″ lift.
- Trim size is interchangeable and conversion is accomplished by merely replacing the plug and seat ring.
- Body materials — Bronze, cast iron, cast steel, forged steel or alloy steel are standard.
- Body design — Globe or angle type bodies, tapped ⅛″, ¼″ or 1″ are standard.

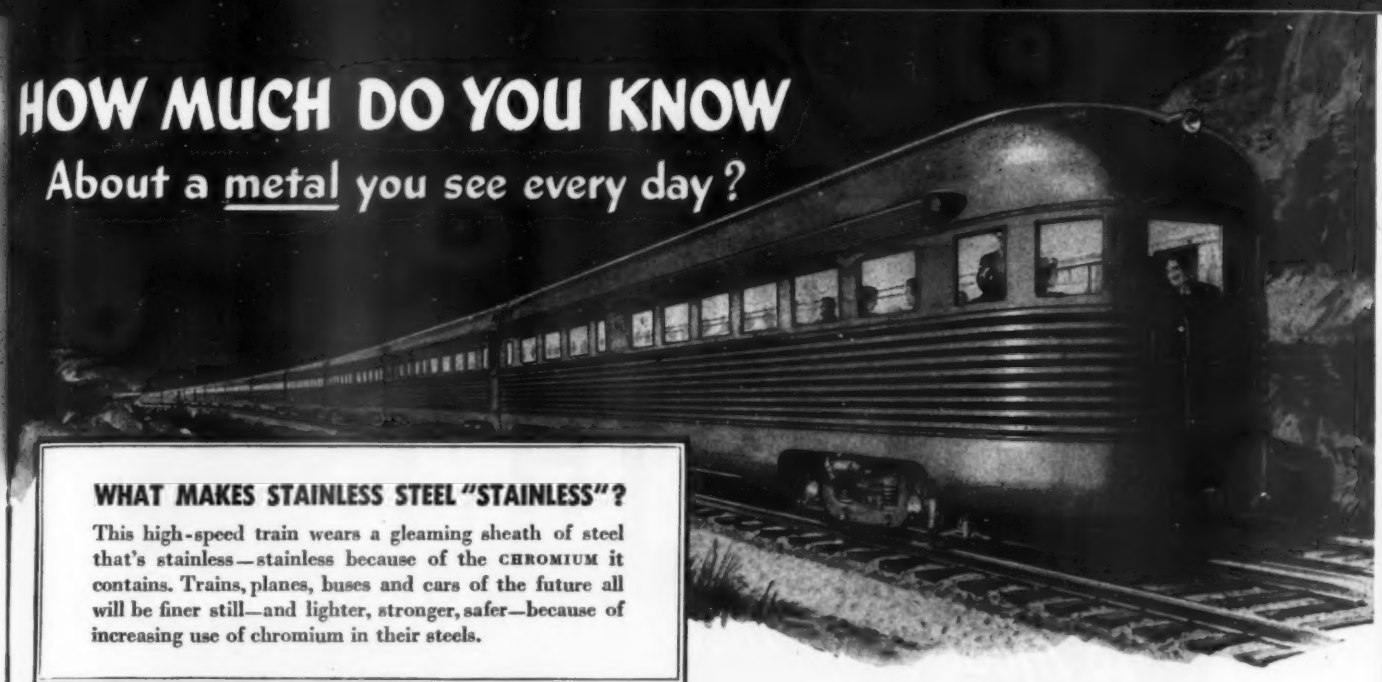
MASON-NEILAN REGULATOR COMPANY

1190 ADAMS STREET, BOSTON 24, MASS., U. S. A.

New York, Philadelphia, Pittsburgh, Cleveland, Chicago, Tulsa, Atlanta, St. Louis, Houston, Los Angeles, San Francisco. Mason Regulator Co. of Canada, Ltd., Montreal, Canada

HOW MUCH DO YOU KNOW

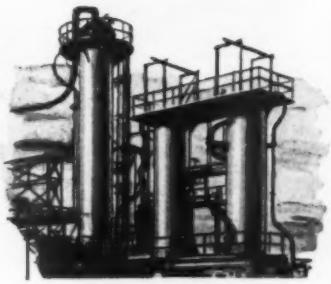
About a metal you see every day?



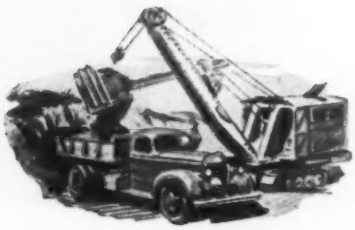
WHAT MAKES STAINLESS STEEL "STAINLESS"?

This high-speed train wears a gleaming sheath of steel that's stainless—stainless because of the CHROMIUM it contains. Trains, planes, buses and cars of the future all will be finer still—and lighter, stronger, safer—because of increasing use of chromium in their steels.

WHY DOES HER KITCHEN COME *"jiffy clean"*?—Sparkling pans, pressure cooker, tableware, shining sink and working surfaces in this modern kitchen all are highly resistant to rust, stain, corrosion—are easy to clean, attractive and long-lasting. Why? Because CHROMIUM has imparted these prized qualities to the steels of which they are made.



HOW DO REFINERIES STAND THE *"acid test"*?—Highly corrosive acids help refine America's oceans of high octane gasoline. But today's refineries withstand fierce acids, high temperatures and pressures—because CHROMIUM stoutly fortifies their metals.



WHY CAN THIS TRUCK *"take it"*?—The steels of many truck and automobile bodies, springs, gears and other parts contain CHROMIUM—for chromium helps give these steels amazing resistance to shock, fatigue, wear.

CHROMIUM is well known to many people for the powerful influence it exerts upon steel. Most of the alloy steels relied upon today for beauty, durability, and resistance to heat and corrosion now contain this interesting element.

Many years ago Units of Union Carbide discovered how to extract chromium from its native ore. They since have been constantly at work on the ever growing list of chromium alloys and their uses.

Union Carbide does not make or fabricate steel. ELECTRO METALLURGICAL COMPANY and other Units of UCC, however, supply to industry such wonder-working metals as chromium, manganese, and vanadium. With these, and the many other basic raw materials produced by UCC, industry improves a thousand and one products that serve all of us.

▼

FREE: "PRODUCTS AND PROCESSES OF UCC," *Booklet P-2, tells an illustrated story of many basic materials industry uses to build this world about us. Send for a copy.*

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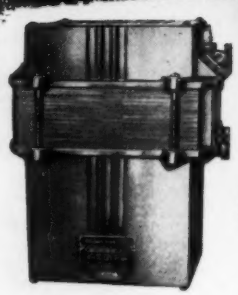
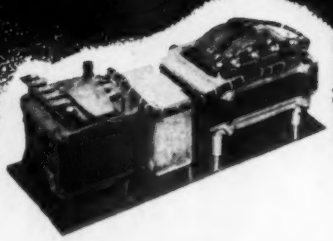
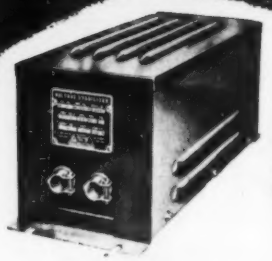
INDUSTRIAL GASES AND CARBIDE—The Linde Air Products Company, The Oxweld Railroad Service Company, The Prest-O-Lite Company, Inc.

THREE DESIGNS

to Meet Your Installation Requirements







Raytheon Voltage Stabilizers

CONTROL FLUCTUATING POWER SUPPLY TO ±½%

One of these three Raytheon Voltage Stabilizer models can do a great job in improving *accuracy* and *reliability* of your electrical equipment... if varying line voltage causes uneven performance.

Smooth out your input troubles. Eliminate power fluctuation. The cost is low. The improvement is often great. And one of these three models will meet your need.

Write today for the complete story—and determine how your own equipment can benefit. Send for our illustrated Bulletin DL 48-537.

Get these principal operating advantages:

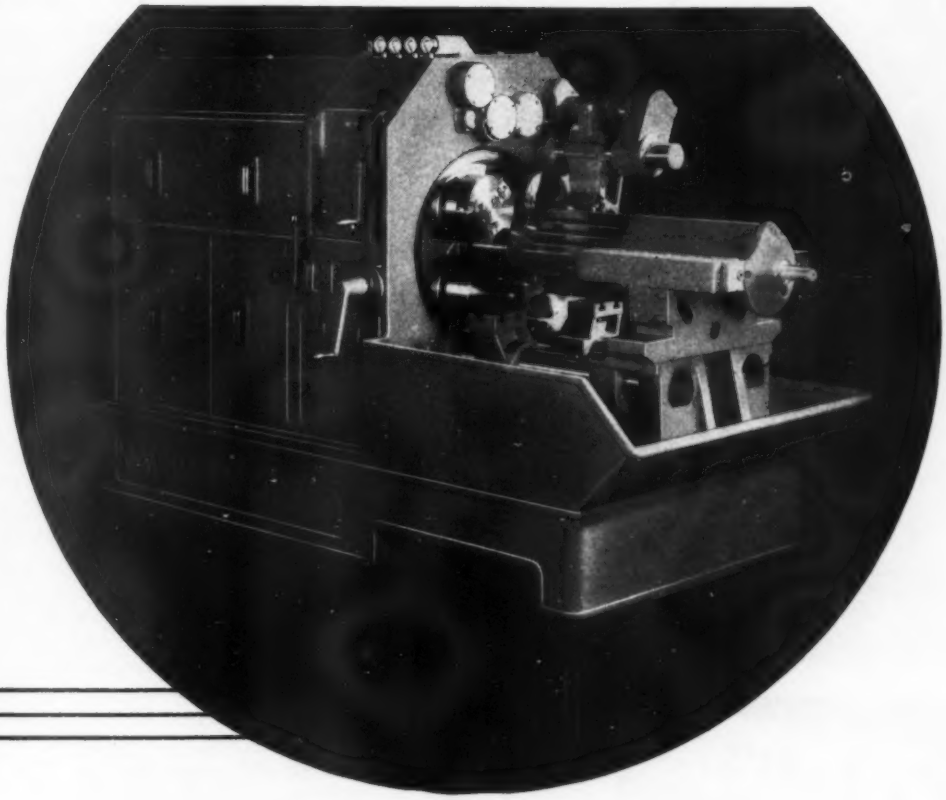
- **Control of output voltage to within ±½% of 115 or 230 V.**
- **Stabilization at any load within rated capacities.**
- **Quick response. Stabilizes varying input voltage within 1/20 second.**
- **Entirely automatic. No adjustments. No moving parts. No maintenance.**

RAYTHEON
MANUFACTURING COMPANY
WALTHAM 54, MASS.

ELECTRICAL EQUIPMENT DIVISION

Excellence in Electronics

WIDE OPEN SPACES MEAN QUICK, EASY TOOLING



There are many reasons why New Britain stands first in multiple spindle automatic chucking machines . . . but none is more important than its wide open accessibility through ***open end construction*** to all tools and chucks, and convenient chip removal. More pieces per hour because no time is wasted reaching for hard-to-get-at points.

New Britain builds a complete line of Multiple Spindle Automatic Chucking Machines . . . four, six and eight spindles up to 12" capacity. Also a complete line of Multiple Spindle Automatic Screw Machines to 2¼" capacity.

NEW BRITAIN AUTOMATICS

THE NEW BRITAIN MACHINE COMPANY
NEW BRITAIN, CONNECTICUT
NEW BRITAIN-GRIDLEY MACHINE DIVISION

M-01

20 SERIES' EASE OF OPERATION
Saves Time in Grinding

Let us show you the production possibilities of these *Electrically Controlled* Plain Grinding Machines.

No.20 (10"x 18")
No.22 (10"x 36")
No.23 (10"x 48")

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BROWN & SHARPE

Here are valuable facts on actual applications of DRY ICE and CO_2 for every potential user of these vital materials—summarized from a recent Liquid survey. All applications listed are in practical use... Many of the wartime functions of DRY ICE and CO_2 have peacetime counterparts—*perhaps in your industry.*

Use this chart as a check-list for possible applications to your processes or problems... DRY ICE and CO_2 serve industry in many important ways including chilling lubricants, shrinking metals, packaging foods, processing oil, controlling paint quality, etc.

Ask for your copy of this free chart today... You'll find it helpful in many ways.

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THE TABULAR VIEW

The Age of the Earth — a somewhat uncertain figure at best — may be ascertained from the facts which astronomy, physics, chemistry, geology, and other sciences place at our disposal. Figuratively speaking, of course, PROFESSOR FREDERICK K. MORRIS unfolds the wrinkles of the earth's careworn features to reveal (page 223) that the geologist and physicist provide only a partial answer to the question, "How old is the earth?" The mere asking of this question, in fact, provides sufficient cause to examine what is really meant by the earth and how we are to measure time, particularly in those distant days when the solid crust on which we abide was in a liquid or gaseous state and the concept of time had not yet taxed man's mental prowess. Fortunately, Professor Morris' clear exposition relieves us of the necessity of becoming engrossed in such abstruse topics.

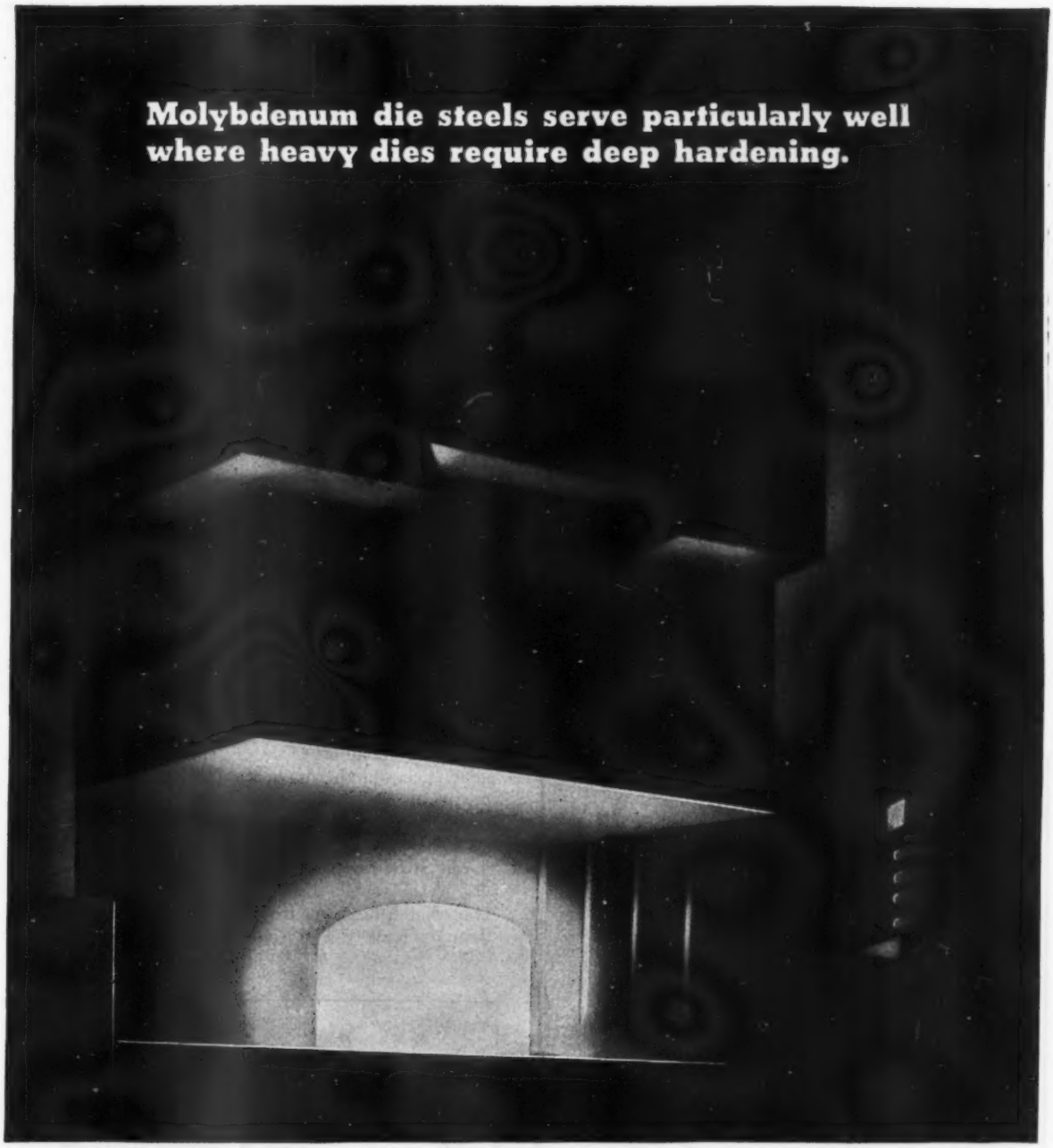
Professor Morris comes from Salt Lake City but obtained most of his early education in New York City. He received the degree of bachelor of science from the College of the City of New York in 1904. Columbia University granted him the degree of master of arts in 1910 and the degree of doctor of philosophy in 1936. From 1914 to 1920 he was instructor in geology at Columbia and then served as adviser in geography to the Department of State in Washington, D. C. Between 1920 and 1922 he established the department of geology at the Government Engineering College in Tientsin.

In 1922 Professor Morris was invited by the American Museum of Natural History to join the Central Asiatic Expeditions into the Gobi Desert as associate curator of geology and geography. In 1927 he was appointed assistant professor of structural geology at the Institute, becoming associate professor in 1928 and professor in 1931.

Technology's Radar School trained more than 8,800 Army and Navy officers and civilians in the principles and techniques of radar between June, 1941, and December, 1945. Normally the end of the war would also see the conclusion of war training programs, but the important work of this school, once shrouded in deep secrecy, is not to be terminated. Rather, as WILLIAM H. RADFORD, '32, Associate Professor of Electrical Communications, discloses (page 227), the war training program has led to a new curriculum in electronics for naval officers, as important in peacetime as the former program was during the war.

Having been associated with the Radar School since its beginning, Professor Radford, associate director of the school, speaks with authority on the school's origin, growth, and activities. After having received the degree of bachelor of science in electrical engineering from Drexel Institute in 1931, Professor Radford came to the Institute and in the following year was awarded the degree of master of science. He has remained at the Institute ever since. From 1932 to 1939 he was research assistant in electrical engineering, being engaged in work at Round Hill, where a program of studies of properties, light penetration, and methods for local dissipation of

(*Concluded on page 214*)



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MOLY

When it's a STARRETT "Mike"

Your machine workers and inspectors take the accuracy of a Starrett "Mike" for granted and what's more, they have no question of your knowledge of tools and your desire to provide them with the finest when you standardize on Starrett Micrometers in every tool crib.

Familiarity with and confidence in the precision tools you provide is an important factor in both the quality and quantity of precision work your shop turns out. That's why it pays to ask your supply house for STARRETT Micrometer Sets.

THE L. S. STARRETT CO., ATHOL, MASSACHUSETTS, U.S.A.

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Shipbuilders and
Engineers

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BATH, MAINE

THE TABULAR VIEW

(*Concluded from page 212*)

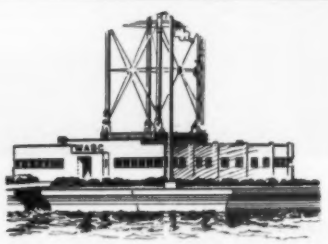
fog was carried out under the direction of Professor E. L. Bowles, '22. Professor Radford has progressively held the position of instructor, assistant professor, and associate professor in the Department of Electrical Engineering.

Technology and Medicine supplement one another in today's medical practice, for new techniques and instrumentalities make possible extension of man's knowledge of man's health. At the Institute the two fields are united in the Department of Biology. The possibilities in the field of applying the principles of the physical sciences to medicine are discussed (page 232) by KURT S. LION, Assistant Professor of Applied Biophysics.

Dr. Lion's education was obtained in Germany, where he completed work for the doctorate at the Technical Institute in Darmstadt in 1932. Following an assistant professorship at this institute, Dr. Lion established his own laboratory of applied physics in 1934 and a year later was called to serve as assistant director of the Institute for Radiology and Biophysics at the Turkish State University at Istanbul. From 1937 to 1941 he was assistant to the director of the Physics Institute, University of Fribourg in Switzerland, and since 1941 he has been with the Institute's Department of Biology. He heads a laboratory of applied biophysics, the activities of which embrace, among other things, the training of graduates in medicine in the application of physical methods for medical practice and research under the sponsorship of the Baruch Committee on Physical Medicine.

Space Station, proposed by the Germans toward the end of the war, is discussed by WILLY LEY, whose portrait sketch last appeared in the "Tabular View" of the January issue of The Review.

Speed with
Economy



We created the island and built this WABC Station on Long Island Sound

The safe way to get speed in building is to engage an organization that has always delivered it. Our reputation for fast, dependable construction dates back to 1917.

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
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Alfred T. Glassett, '20, Vice President

Is THIS the Answer to Your Problem?

The use of SANDEE Extruded Plastic Strips and Sheets is growing rapidly for a great variety of punch press operations. It is made in various thicknesses up to 3/16 inch and widths up to 10 inches. Plain strip or ribbed contours in a wide range of colors are shipped in rolls for continuous feeding or in cut lengths. SANDEE Strips and Sheets are satisfactory for beading, forming, blowing, heating, drawing and general fabrication, on most existing equipment. Let SANDEE plastic engineers suggest the composition of materials best adapted to your needs. All orders manufactured to specifications only. No stock. Ask today for free samples and the cooperation of our capable technical staff. This service involves no obligation.

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washers
blanks
decorations
discs for toys and games
insulators
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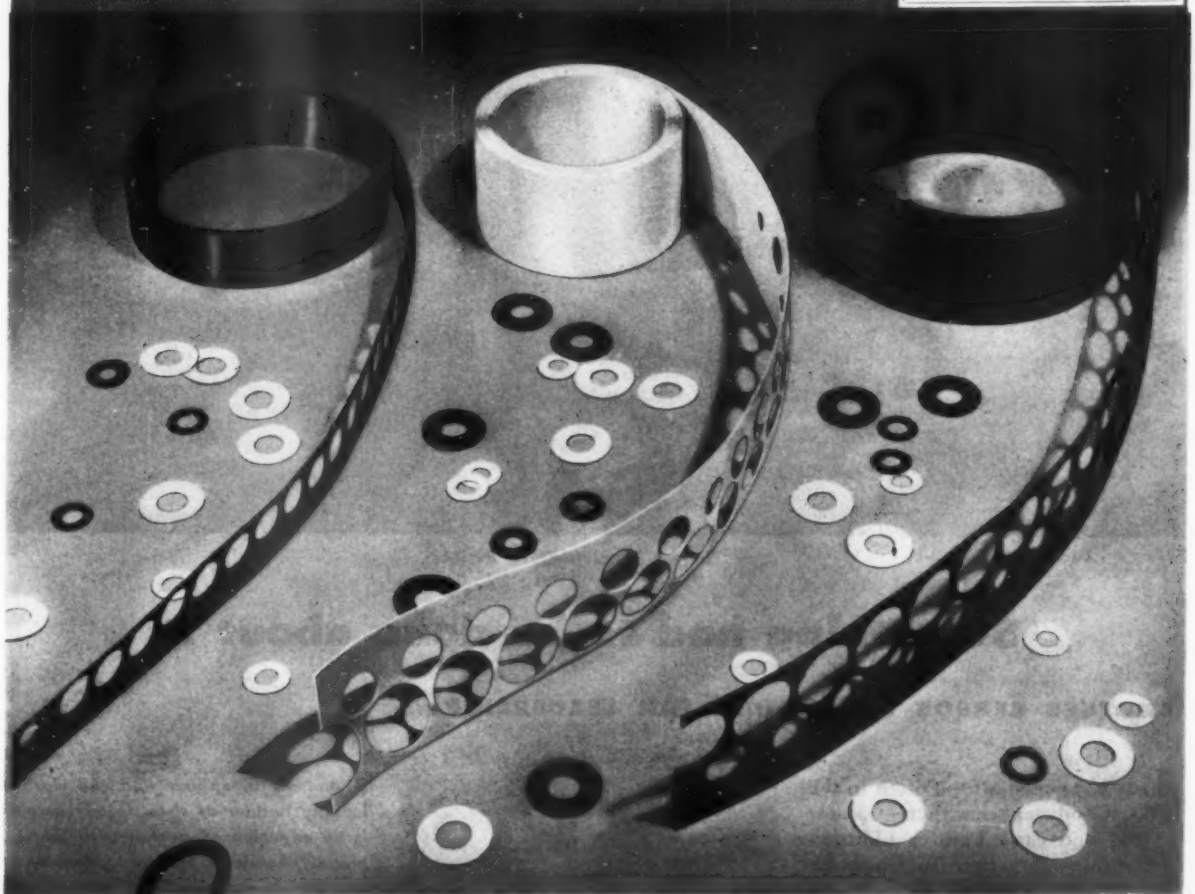

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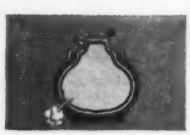
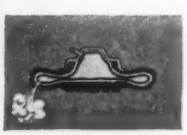


1. Ordinary tube has but one air chamber. If tire blows, tube blows, too.



2. Instantly both tire and tube go flat, frequently throwing car out of control.

3. The LifeGuard has two air chambers. If tire blows, only outer chamber flattens.

4. Air in reserve inner chamber supports car for a safe, gradual stop.

A pioneer in rubber and the world's leading builder of tires, Goodyear also is an experienced worker with fabrics, metals, chemicals, plastics . . . constantly developing new products that will be more useful to you.

GOODYEAR

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VOLUME 48 NUMBER 4

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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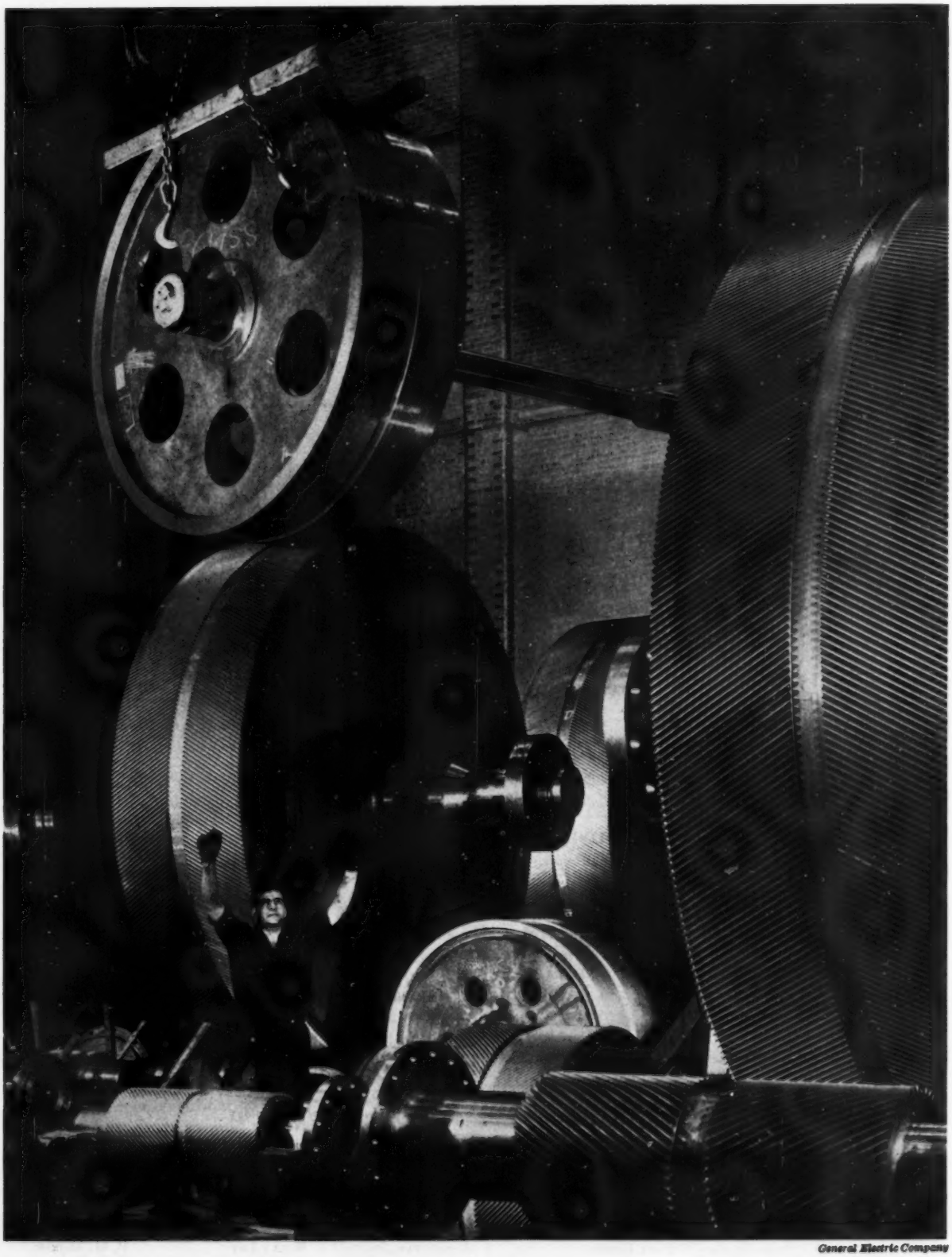


General Electric Company

Giant Marine Gears

THE
TECHNOLOGY
REVIEW

Vol. 48, No. 4

February, 1946

The Trend of Affairs

Bittersweet

STEREOISOMERISM, differences in the spatial arrangement of atoms within molecules, may differentiate physiologically valuable from physiologically inert substances (as demonstrated in "Chemistry in Three Dimensions" in The Review for March, 1944), but other, almost equally subtle, alterations in molecular constitution may change beneficial substances to actually harmful ones. Take, for example, histidine, a nutritious amino acid, a component of proteins. By simple loss of one carbon and two oxygen atoms, a change known to the biochemist as "decarboxylation," the molecule of histidine is converted to that of histamine, a hormone-like substance. Histamine has been assigned a number of functions in human physiology, mostly functions of an adverse nature. For instance, histamine has been implicated in allergies. It is also thought to be the chemical mediator in cutaneous pain, which means that when skin is subjected to painful stimulants such as high heat or mechanical irritation, histamine is released from the skin tissues and affects sensory nerve endings to produce the sensation of pain.

Chemical similarity between beneficial and harmful compounds may also be found among the vitamins. Pyrithiamine, a slight modification of thiamine or vitamin B_1, not only lacks the vitamin effect of thiamine but also is capable of "blocking" thiamine. Such blocking occurs when pyrithiamine is administered to an animal whose diet contains ample thiamine; pyrithiamine then displaces thiamine from the complex reaction systems of carbohydrate metabolism where thiamine ordinarily performs its valuable functions. Thus, since pyrithiamine has no vitamin value, a condition of thiamine deficiency is produced. This antivitamin effect of pyrithiamine is useful to the experimental physiologist who may, by administration of pyrithiamine, produce thiamine deficiency in laboratory animals at will, regardless of the thiamine content of the animals' rations.

A familiar physiological differentiation between similar organic compounds occurs among the sugars. Taste is purely a subjective sensation that may not be gauged by objective measurements; hence difference in sweetness of various sugars is truly a physiological differentiation. Glucose (dextrose or corn sugar) and fructose (levulose, a sugar of honey) have exactly the same empirical formula, $C_6H_{12}O_6$. These sugars have, furthermore, only minor differences in molecular structure. Both are straight chain compounds, but in glucose an oxygen atom is attached by a double bond to a terminal carbon atom, whereas in fructose the corresponding oxygen is attached to the next-to-the-end carbon. Despite this almost identical chemical constitution, glucose and fructose differ markedly in sweetness. On the basis of the widely used sweetness scale, in which sucrose, common cane sugar, is taken as the index and is assigned a sweetness value of 100, fructose has a sweetness of 150 and is the sweetest of the commercially used sugars. Glucose, on the other hand, has a sweetness value of but 60. This relationship has led to the recent perfecting and patenting of a process for converting glucose to fructose in order to increase the sweetness supplied by a given amount of sugar; for the prime characteristic of any sugar is sweetness.

A most striking example of physiological differentiation, again a difference in taste, also occurs among the sugars. Sucrose, as we have seen, is used as an index of sugar sweetness and is, in fact, the sweetest sugar except for fructose. Yet when the eight hydroxyl (OH) groups of the sucrose molecule are replaced by acetyl (CH_3CO) groups, the resultant compound, sucrose octa-acetate, is one of the most intensely bitter substances known.

Enzymes in Industry

NEWS that the textile industry is currently consuming about 2,000,000 pounds of powdered enzymes and about 15,000,000 pounds of enzymes in liquid form each year draws attention to one of the most unusual of indus-

trial chemicals. Enzymes are protein catalysts produced in infinite variety by all living organisms. Of the thousands, if not millions, of specific enzymes believed to exist, only about 30 have so far been obtained in purified, crystalline form. All of this handful have proved to be large protein molecules, beyond the chemist's present power of synthesis.

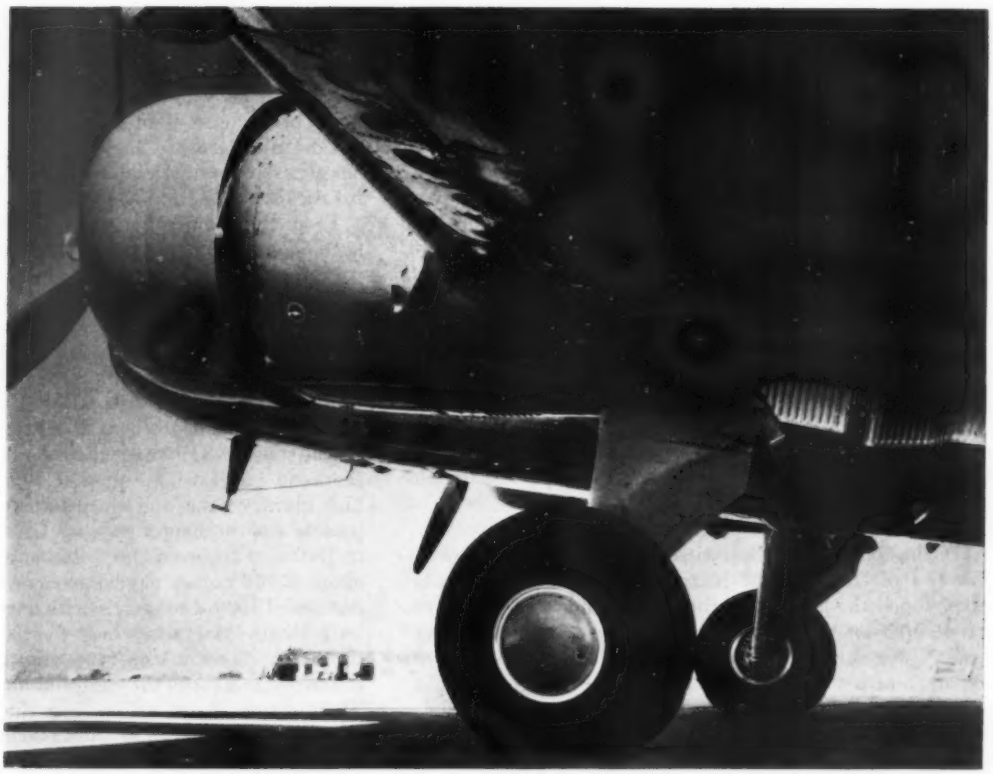
Reactions that proceed at all in the laboratory only by use of high temperatures or harsh chemicals, or proceed too slowly to be practical economically, advance smoothly at low temperatures and under mild conditions in the presence of the correct enzyme. So limited, ordinarily, is the range of reactions which a given enzyme will accelerate that some biologists visualize a "lock and key" arrangement between a specific enzyme and the particular type of protein, fat, carbohydrate, or other substance that it affects. Like other typical colloidal substances, enzymes are also quite sensitive to the degree of acidity or *p*H of the medium in which they are operating and to temperature, most of them being inactivated by temperatures well below the boiling point of water. This is not too surprising in view of the fact that by nature they normally function, in most cases, at blood temperature or below. In common with other proteins, enzymes can also be attacked by microbes and therefore must be produced and stored in sterile surroundings. But when enzymes are placed in the proper environment, they can be effective in extremely small amounts. Invertase can hydrolyze one million times its weight of cane sugar without appreciable loss of activity. Catalase obtained from beef liver (differing slightly from catalase obtained from sheep or pig livers) will decompose hydrogen peroxide when diluted to one part in 25,000,000. Enzymes also work at low concentrations when in the organism, the concentration of an individual enzyme within the living cell ordinarily being in the order of 0.01 per cent. It is possible, however, for a cell to contain hundreds of different enzymes, since most of the cell's protein content, exclusive of the structural proteins, may consist of them.

The direct use of more or less pure enzymes in industry may be considered to have started about the beginning of this century with the work of J. Takamine, who isolated and commercially applied certain enzymes obtained from molds. The same molds had been quietly working for centuries, however, producing the same enzymes which, quite unknown to the brewers, were responsible for the Japanese national beverage, sake. Similarly, other enzymes produced *in situ* by appropriate strains of yeasts and other microbes have made possible the production of wines and beers, the making of bread and cheese, the curing of tobacco, the bating of leather, the retting of flax, and many other ancient arts. Modern fermentation processes that yield citric acid, butanol, and other organic chemicals also depend on specific enzyme systems.

Industry uses enzymes instead of chemical or biological agents because greater control and better quality can thus be obtained. Occasionally the presence of micro-organisms would be undesirable. With enzymes, aseptic conditions may be maintained. Just the right amount of enzyme to carry the reaction to the point desired can be used, and the reaction can further be controlled by varying *p*H or temperature. Thus the bating of leather was originally accomplished by introducing into the liquor surrounding the hides the excreta of various animals. Later it was recognized that either pancreatic juices or certain strains of microbes found in these excreta were the motivating agents. The use of cultures of these microbes in the leather pits was not always successful, however, for many exter-

Shigeta-Wright, Inc.

The Nineteenth Century iron horse enabled our grandfathers to develop this nation's industrial resources, but . . .



. . . the silver bird of the Twentieth Century makes all the world our province for building friendly relations.

nal conditions could modify the rate at which the microbes secreted their enzymes, and the leather would emerge too soft or with other failings. More precise control was obtained when the isolated enzymes, today obtained from the pancreas or from certain molds, were used.

Enzymes are used in the textile industry (and also in paper making) to reduce the viscosity of the starch and casein sizing materials without unduly reducing their strength, the use of raw starch and casein having virtually disappeared. Later, when the sizes must be stripped off the cloth in preparation for such steps as dyeing, enzymes are again summoned, this time to digest the size completely.

Enzymes are frequently used to change carbohydrate molecules so that they become more soluble or fermentable. The brewer can thus produce more alcohol from a ton of wheat or corn, and the candy maker can produce syrups of high density which will not crystallize. The soft center in chocolate candies owes a debt to the enzyme invertase, for by adding a small amount of enzyme to an easily handled hard center before it is dipped, the center will later soften to the required consistency because of the breaking down of the sugar by invertase.

Expendable Optics

BECAUSE of their unexpectedly crystal-clear transparency, more than casual interest has been given to a group of plastics which have been developed within the past decade. Boudoir items, in which decoration vies with good taste — and frequently becomes victor — have provided the principal commercial applications for molded plastic "crystalware." But combs, picture frames, or cigarette boxes have by no means exhausted the possibilities of the more recent additions to the family of plastics. Freedom from color, lightness of weight, and high transparency, coupled with the comparative ease with which they may be molded inexpensively on a mass-production basis, hold promise that transparent plastics will be welcomed in the field of optical engineering.

Some of the first samples of methyl methacrylate to be brought to this country from England were molded into optical elements for inexpensive cameras, and tolerably good photographs were made with simple plastic lenses of a decade back. Since then, rapid strides have been made in the production of lenses, prisms, and other optical elements which are molded from plastic instead of being laboriously ground and polished from crown or flint glass. Already plastic optics has been used in the manufacture of wartime telescopes, binocular attachments, and in an experimental aerial camera lens.

Experimental work in the field of television has brought forth the design and construction of a plastic correcting lens for use in projection television receivers. Because of the unusual curvature of the lens, its large size, and the need for mass production at low cost, plastic optics finds a natural application here. In fact, glass optical elements would be out of the question for this particular application because of economic factors, even if glass of the required size and shape could be made in the quantities required.

No new process or development ever completely supersedes that which it replaces, and certainly it is too much to expect that present molded plastics will provide serious competition to glass in the optical industry. As might be expected, molded plastics have their drawbacks as well as their advantages. They are soft and easily scratched. They are not available in the range of refractive indices obtainable in glass, although polystyrene

may be used for elements ordinarily made from flint glass and the characteristics of crown glass are met by a plastic bearing the mouthy name of polycyclohexylmethacrylate. It is, of course, necessary to consider these factors in applying plastics to optical systems.

But against these disadvantages, plastic optical elements have features making them well suited to the production of large, nonspherical optical parts. Moreover, molded plastics are well adapted to mass-production techniques and can be produced at low cost with sufficient precision for certain kinds of optical parts. Where lightness of weight is important, they more than compete with glass. Inexpensive cameras, opera glasses, telescopes, and perhaps even toy microscopes come to mind as legitimate applications. But the low-cost feature (where quantities of identical units are required) makes molded plastics well adapted to the field of expendable optical instruments.

Space Station

By Willy Ley

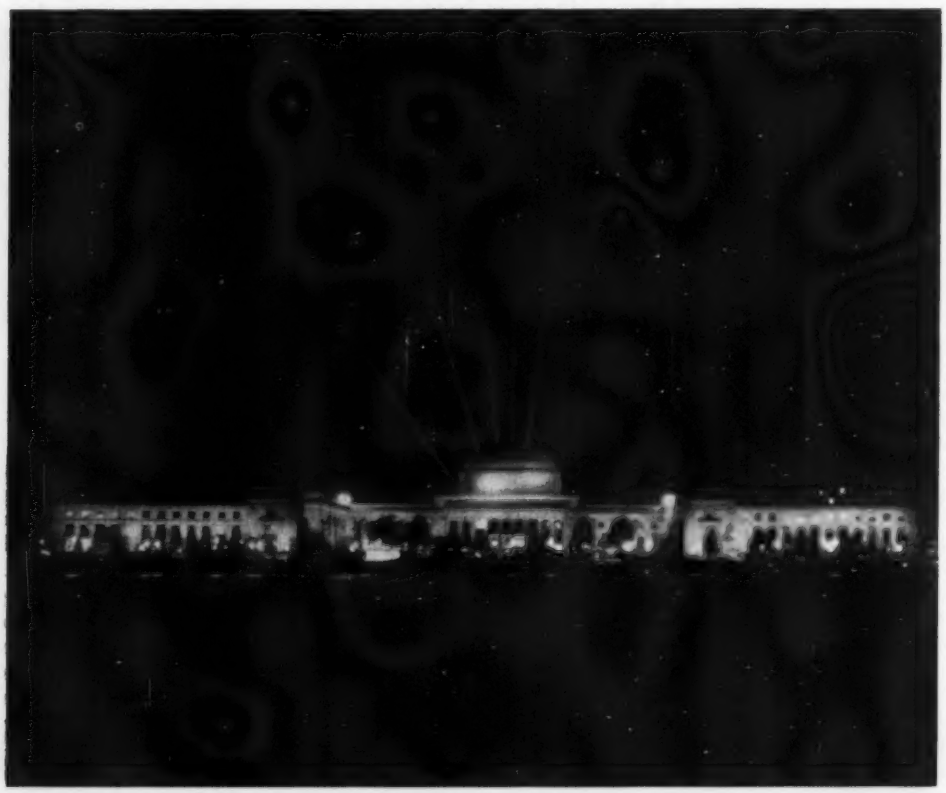
IN the course of the investigation of the scientific activities of the corps of Nazi rocket-research men, who developed the long-range rocket V-2 and were busy with the super-long-range rocket V-3 at the time Nazi Germany was subjugated, preliminary plans for a station in space and a so-called "sun gun" were brought to light. The report stated that there were found such plans for a station intended to circle the earth some 5,100 miles above the surface.

It may be doubted that whatever plans have been found can justly be called preliminary plans. The Nazi scientists themselves regarded the station in space as a postwar plan, roughly half a century in the future. Any plan which looks that far ahead has, of necessity, to be sketchy; there is no way of telling how one would build something 50 years from now. The proposal could not have been more than a set of calculations about the optimum distance of such a station, essentially a rather simple astronomical problem, modified only by the values for rocket thrust, and so forth, used in the assumptions.

From the engineering point of view it can be said that such a station in space is definitely feasible provided rockets of sufficient magnitude and thrust power are available. As a matter of fact, the whole problem is by no means a novelty, and the strangest aspect of the whole story is the attitude of the investigating officer who quickly credited the German general staff with the inception of the idea and who put the responsibility for this "fantastic scheme" where it did not belong at all.

The space station made its first appearance in a German fantastic novel which showed the rare combination of high literary value and scientific accuracy. Written by the professor of mathematics Kurd Lasswitz, it was published in 1897 and achieved the status of a steady seller, selling about 2,000 copies a year every year from publication date until 1930. In the Lasswitz novel the space station is built by the Martians whose spaceships cannot approach the earth directly since the moisture in the terrestrial atmosphere attacks the material of which they are built. The distance of the station from the center of the earth is one earth diameter, or about 4,000 miles from the surface.

The first scientific book in which the station in space made its appearance was Professor Hermann Oberth's first work on rocket theory, published in Munich in 1923. Oberth conceived the structure (*Continued on page 252*)



Crown — or Spanish Comb? Once more flood-lighted at night, the Institute took on added splendor during the Victory in Science exhibit held in the Great Court on November 10 to 12, when a group of Army searchlights produced these shafts of light radiating from the main dome.

The Age of the Earth

Physical Chemists, Astronomers, and Geologists Unite Their Knowledge to Fix Three Billion Years as a Conservative Estimate of the Earth's Age

By F. K. Morris

TWO camps of experts have given all the estimates which are used in most writings and lectures to estimate the age of the earth. The astronomer estimates the age of the sun and so limits the age of the planets, which are the sun's children. The other group answers to such names as "geochemist," "physical chemist," or "expert in radioactivity." They study the disintegration of uranium, thorium, and other radioactive elements, and, by accurately weighing the relative amounts of disintegration products, they can tell how many years have passed since those atoms of uranium were enclosed in a crystal — that is, they tell the length of time since a given rock crystallized. This method has been triumphantly successful, and all men have accepted its results. The ages of our oldest rocks have been reckoned at 1,500,000,000 years, more or less, and the bet is on the plus side.

All popular discourses and even some technical reports call these time estimates "the age of the earth." On my bookshelf within easy reach I see a volume bearing this very title, and opening it, I find a symposium on the ages of certain samples of rock as estimated by their radioactive elements. The ages of these rocks are not the age of the earth; the crystallization of rock marks only one date in a much longer history of the earth.

Now where is the geologist all this time — he whose very name should make him custodian of the logos of the earth? His chief job has been and still is to study the details of the earth's visible rocks and put together in time sequence a vast history of fact about the earth. My memory easily recalls the time when geologists accepted a story of the earth, a story so complex that it must be long, so long that it covered a period which exceeded the time which astronomers of that day allowed for the formation of the whole solar system. Later, most fortunately, the science of astrophysics lengthened its time scale so that the geologist's earth could fit into it. And now let the geologist try to tell the age of the earth, humbly acknowledging the help of his colleagues in physics, chemistry, and astronomy.

We look first at the bedded sedimentary rocks, shales that once were muds, sandstones that were loose sand, and limestones, most of which were made by living creatures. Little more than a century ago, when men began seriously to study the earth by means of fact and inference from fact, the simple but immense truth was discovered that the younger beds of rock lie on top of older layers. This discovery represents a truth that is valid across the whole world, and by it alone the entire sequence of the rocks is made out.

Beginning anywhere you please, on any continent, but preferably in some broad plain where the rock layers are but slightly tilted, we follow down the sequence of rock layers. The older rocks lie beneath the younger ones, and then we find still older rocks under them, as shown in Fig. 1. Allowing for folding and erosion, we estimate time. Backward and downward we read into the past, guided unerringly by our principle of superposition until suddenly we come to granites and must pause to consider their significance.

Long ago, all granites were hot solutions. They could become part of our rock sequence in just two ways, by encroachment or by replacement. According to the first possibility, a great body of hot liquid granite may rise slowly from deep within the earth and encroach upon the overlying rocks, splitting them, melting them, or dissolving blocks of them, until granite liquid occupies the place where bedded rocks formerly existed. This encroachment continues until the liquid crystallizes into solid rock and ceases to invade. In Massachusetts the granite of Quincy came in this way as a huge body of granite liquid.

Alternatively, escaping hot solutions may rise from a

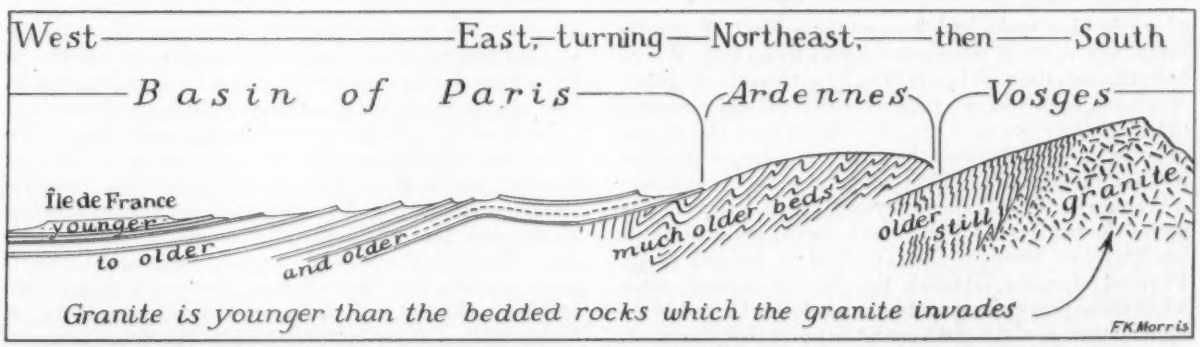


Fig. 1. The section shows how the geologist proves that older beds of rock lie underneath younger beds. The diagram takes a liberty with geography, for a wing of the Paris Basin intervenes between the Ardennes and the Vosges, but the age succession is correctly shown.

deep-lying mass of granite liquid and may slowly traverse the overlying rocks — stealing through them, intimately penetrating them, giving them heat, fluid, and chemical reagents, helping them to reorganize and change. Ever so slowly these hot juices work upward out of the granite liquid and through the bedded rocks, dissolving the original materials and replacing them with the stuff that makes granite. In Massachusetts the granite of Fitchburg was made in just this way, by replacing bedded rocks that began their story as ancient sands and muds.

In either case — whether the liquid granite invaded the bedded rocks directly or whether those rocks were slowly replaced almost molecule by molecule until granite sat

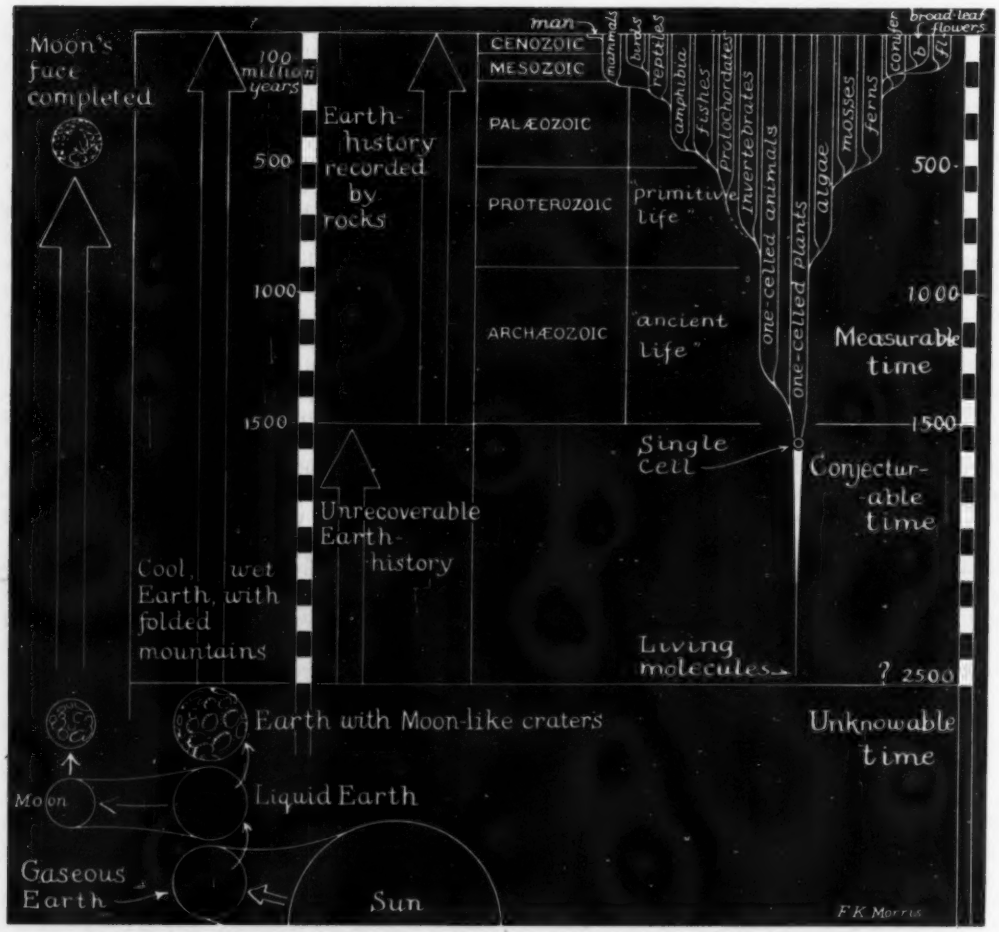


Fig. 2. A summary of the earth's history extends up the middle of the diagram, flanked by a history of the moon and of life. The oldest events are at the bottom. The left-hand earth-column shows but two chapters, a cosmic chapter and a long, cool-wet-earth chapter. To the right, the latter is subdivided progressively until the geologic eras are laid out in their true relation to the time scale.

where bedded rocks had been — the advent of granite brings our story of superposed layers to an end. We go back through the rock layers (Fig. 1) as through the pages of a book, from younger pages to older and older records until suddenly we meet granite. There ends the record of geology, for we see that the granite is younger than the rocks it invades. The oldest samples of rock which our colleagues in physical chemistry analyze to determine the age of the earth come from these invading granites which are therefore younger than the oldest bedded rocks. Physical chemists establish the very important dates when those particular granites invaded; but they shed no light on the age of the earth except to prove that it is great.

Now come out with the geologist and look at the truly oldest rocks, the bedded rocks which the granite invades. You will have to accept a lot of guidance or else take a course in geology to follow all of the points to be enumerated. But the geologist will prove to you that the bedded rocks of ancient time included fine clayey muds, thin-layered and of vast extent, such as are laid down in large bodies of shallow quiet water. They were muds which long, slow rivers brought down from broad, low, stable lands. The geologist will show you beds that were sandstones long ago, beaches and near-shore deposits, deltas of rivers reaching out into shallow seas. He will show you lavas and ash beds, no bigger than those of much more recent eras and certainly none that would hint that the earth was much warmer then than now. He will show you rubbles that were trundled along by icy glaciers in those long-ago ages and even limestones and black carbon that clearly imply the abundance of living creatures.

In short, he will show overwhelming proof that, at the oldest age recorded by rocks, the earth was as cool, as wet, as quiet, and as hospitable to life as it is today; that life itself was already old. This conclusion is the true meaning of the important researches into the age of ancient granites. These excellent studies prove that 1,500,000,000 years ago was the time when we lose touch with legible bedded rocks but not the time when such rocks began to be made. Fifteen hundred million years ago is an essentially modern date in the story of the earth.

We must infer a long era of cool-wet-earth history before our legible record begins. It is as though the history had been written in a great book whose leaves are layers of rock, and the first half of the pages had been torn out and burned in a furnace of hot granite. During that long era for which the rock record is lost, life must have commenced as a complex chemical process in sunlit, quiet waters. No bigger than molecules at first, the early living creatures evolved very slowly until, even before the legible rock record begins, they had attained the high complexity of one-celled plants and animals.

Thus we need a long time for the unrecorded cool-wet-earth era, long enough for an evolution as important (and almost as complex) as all that life has done since simple cellship was attained. Life could not possibly have begun until the earth was cool. In Fig. 2 is indicated a cool, moist, unrecorded era of uncertain length, but long enough to contain the beginning of life, and that may well mean as long as all time since the rock record began.

Now we shall turn to the astronomer and here our job is easier. He tells us that the earth and moon came from the sun but that no one knows how. It is almost a comfort to have no theory at all for that saves the row of conflicting theories. But we may be sure that when the earth came from the sun it was as hot as the sun itself. Hence we can confidently infer a hot-earth chapter during which the earth changed from a gaseous to a liquid body and thence to a planet whose thin crust still felt the heat of a liquid interior. In this last stage, most of its mountains were volcanoes and must have rivalled the craters of the moon.

Here the moon begins to help us, for it has kept the very features that formerly characterized our planet. We see mirrored in the moon a smaller image of the earth when its internal heat energy found vent in ring-shaped mountains, lava floods, and lifted or sunken fault blocks. The moon had no other way of making mountains except by volcanoes and very moderate faulting while the cool-wet earth learned a new way of making mountains, as we shall see. One of America's ablest geologists has recently published a book on the moon[1] in which he clearly distinguishes older features from newer ones on the moon's face and proves that the moon's readable story is very long. I would go a little further and claim, without fear of contradiction, that the moon must have been active until a fairly late period. I care not a jot whether you agree with closing the moon's cosmetic life about the end of our Palaeozoic era as is shown in Fig. 2. You are welcome to a plus or minus of many million years on the date when the moon forswore her compact for the rest of eternity and ceased to make up her face. But the moon's latest craters and their bright streaks of ash could not

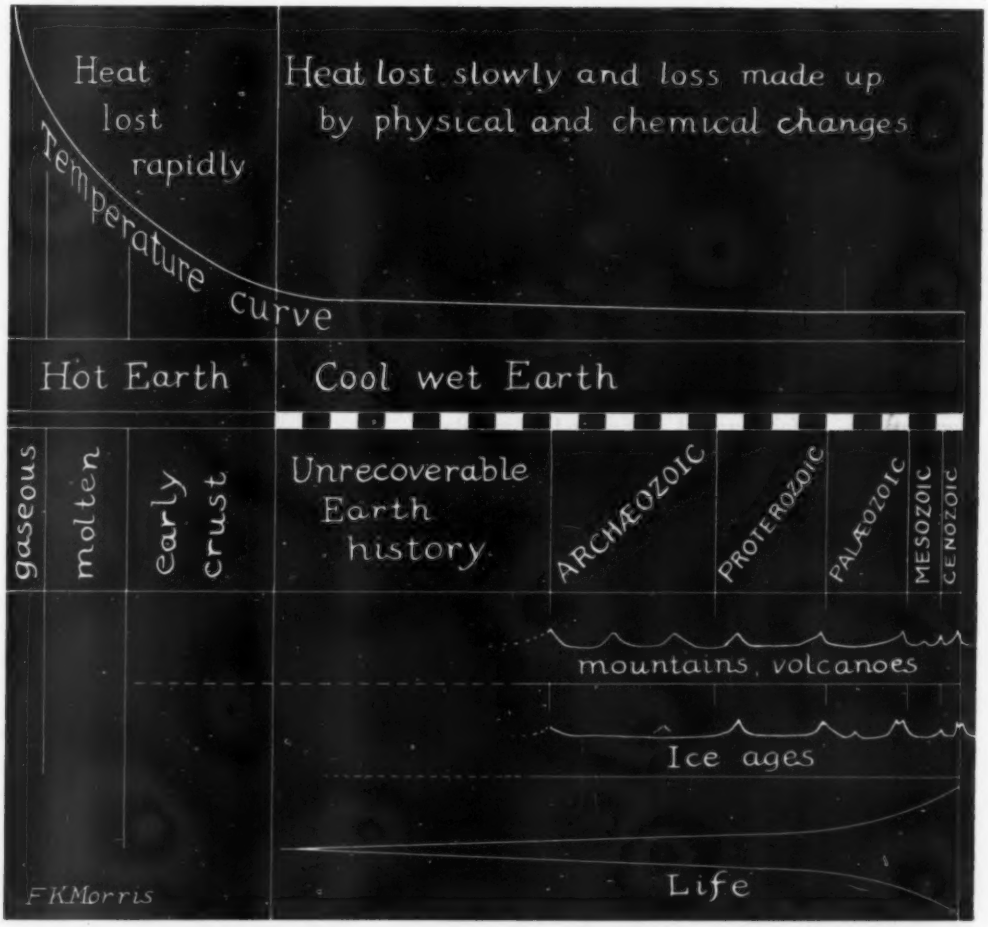


Fig. 3. The most important part of this figure lies at the junction between the Archaeozoic era and the era of unrecoverable earth history. The four curves, representing earth temperature, mountain-making, ice ages, and the development of life, show that at the earliest time recorded by visible rocks, the earth was in essentially the same condition as at present. Each black and white bar represents 100,000,000 years.

[1] Josiah Edward Spurr, *Geology Applied to Selenology* (Lancaster: Science Press, 1944).

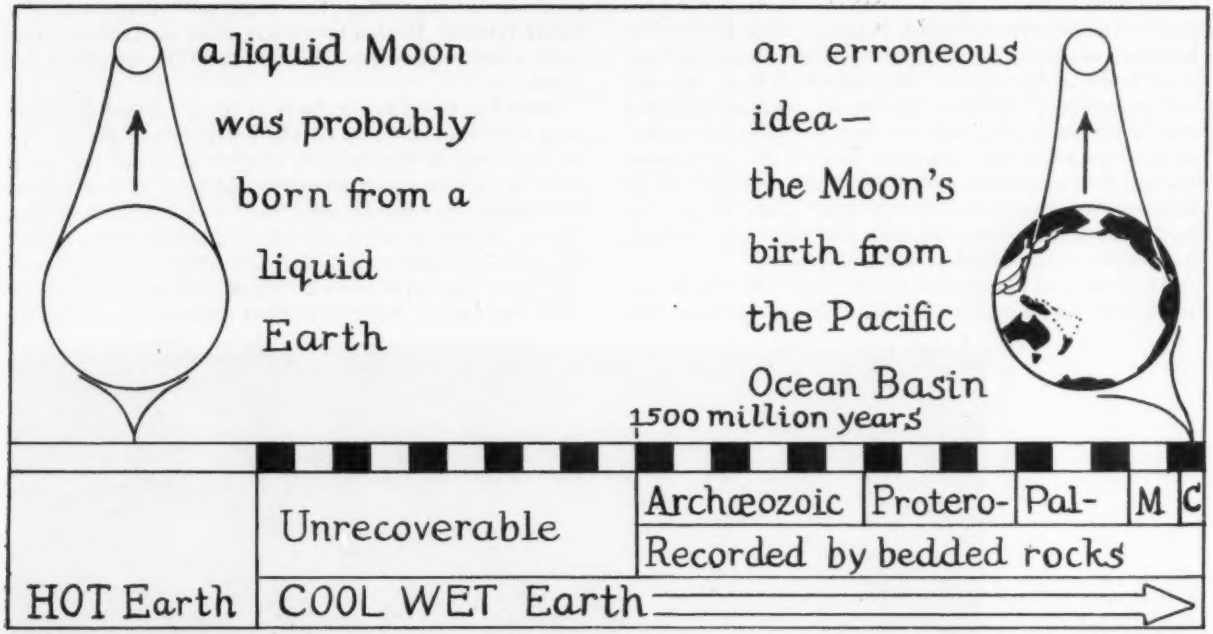


Fig. 4. This diagram illustrates the critical importance of the time scale in discriminating between incorrect ideas and inferences that can be supported by fact. The text explains the vast differences in time between the birth of the moon from the Pacific basin and its birth from the liquid earth.

keep their brilliant freshness forever, even on the moon. They must be of fairly recent origin, and I have dated them about 200,000,000 years ago.

On the much larger earth, seas formed when the crust was thick enough to shut in the internal heat. Ever since sea and land existed, rivers have eroded the land and carried the shavings into the sea. Whenever these muds have become very thick, the earth has folded them to form mountains like the Alps, Appalachians, or Himalayas. The cool-wet chapter of earth history has been characterized by folded mountains made of bedded sediments.

The age of the earth offers an acid test for some of the beliefs that are held not only by the man in the street but are heard even in major universities. I shall touch but one of these: Did the moon come out of the earth, and if so, when? That brilliant mathematician and scholar, Harold Jeffreys, shows that the earth by its own energy could never have given birth to the moon.[2] He holds that it is just within physical possibility that the sun might have aided the moon's birth by a series of rhythmically repeated tidal pulls, which he calls "tidal resonance." The earth must have been wholly liquid, must have been rotating more rapidly, and must have been nearer the sun than it now is.

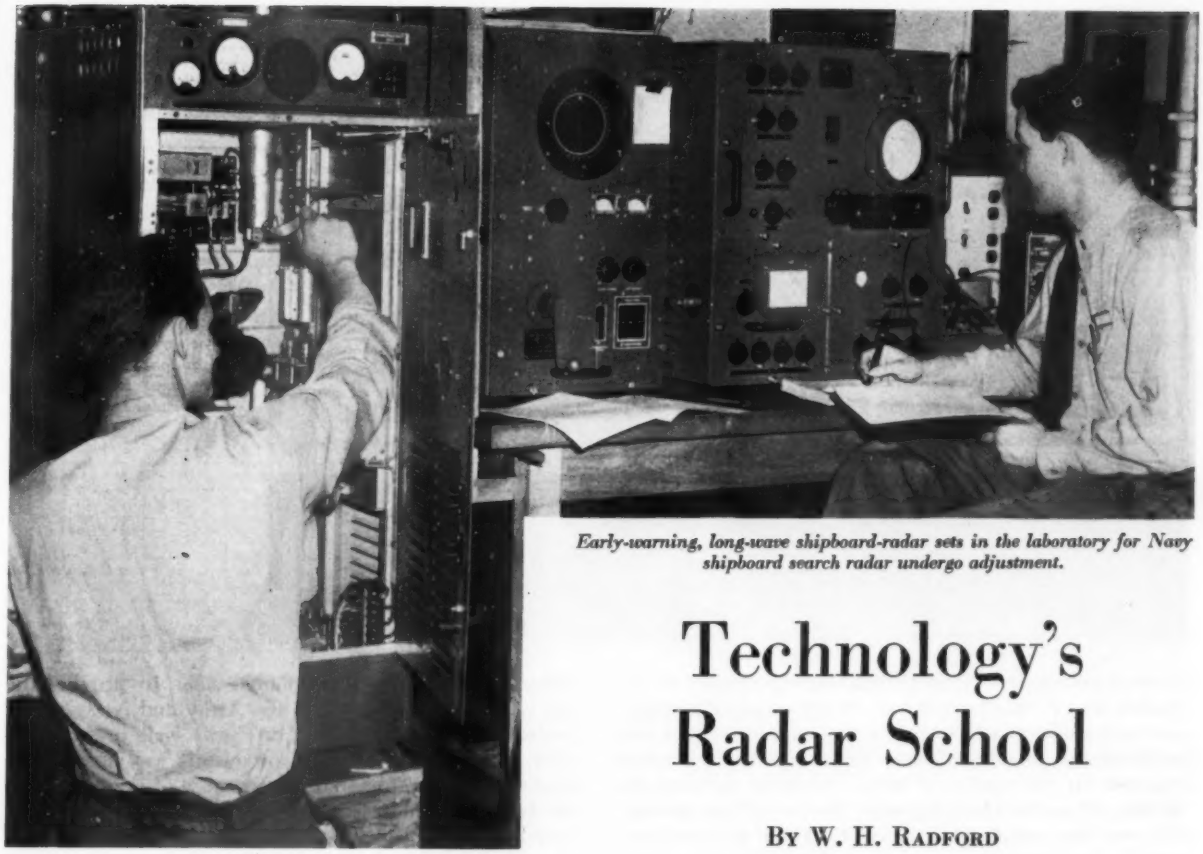
When, if ever, could this separation have happened? Only once were all necessary conditions favorable, and that time was during our hot-earth chapter. At the left of Fig. 4, you see the moon coming out of the earth during the molten period; and on the right is drawn the birth of the moon as fancied by most people, including, alas, many university instructors and not a few lecturers. These good people point to the huge round hole, which contains the Pacific Ocean, as the scar of amputation whence the moon was torn from the earth. They point to the volcanoes, active or but recently extinct, that rim the great hole and tell us that the earth is still bleeding lava and trembling with earthquakes around the margin of the scar.

This theory is poetry, not science. In quantitative fact, the moon is many times too big to have come out of the Pacific or out of all the earth's ocean beds combined. The moon is too old, for we can date the Pacific volcanoes and show that they belong to the very latest period of volcanism. We can date the depths and heights that rim the Pacific and show that they too were made well within the Age of Mammals. The age of the earth measures the magnitude of the libel we commit if we say that the moon might have come out of the Pacific basin.

The history of volcanoes agrees with the history of bedded rocks in pointing toward a long unrecorded era of thick-crust earth, which necessarily is the same as cool-moist earth. We find some volcanic action in all ages; but at times when big blocks of the earth's crust are heaving up or down along great faults, large volcanoes burst forth and floods of molten lavas pour out of fissures and cover vast areas. This action may continue for some millions of years before the volcanoes die out, the lava floods cease to flow, and a major volcanic period is past. Busy rivers then tear down the high volcanic cones and wear away vast amounts of the plateau lavas until only a geologist can prove that there was a volcanic period. After long quiescence — tens or hundreds of millions of years — new movements of the earth's crust begin, and new major volcanoes and lava floods appear, this time in quite different regions.

Looking back into the long recorded history, do we find that the older ages had more and greater volcanoes, bigger lava floods than those of later times? The answer is no, not in the recorded era. In Fig. 3 (*Concluded on page 252*)

[2] Harold Jeffreys, "The Origin of the Moon," *The Earth, Its Origin, History and Physical Constitution* (New York: Macmillan Company, 1929).



Early-warning, long-wave shipboard-radar sets in the laboratory for Navy shipboard search radar undergo adjustment.

Technology's Radar School

By W. H. Radford

With a Record of 8,800 Persons Trained in Radar Techniques, the Institute's Largest War Training Facility Is Being Converted to Provide a New Electronics Curriculum for Naval Officers

ESTABLISHED at Technology almost six months before Pearl Harbor, the Radar School composed the Institute's largest specialized war training activity. Unique in many respects and noted for the variety and high standards of its courses during the war period, the school served as one of the principal centers for training Army and Navy officers in the theory and applications of radar. At the completion of the war phase of its operations in December, the school had trained approximately 8,800 officers, enlisted men, and civilians, including practically all of the Naval Reserve "electronic specialist" officers who were responsible for procurement, installation, and maintenance of the air-borne and shipboard radar and related electronic equipment of the fleet.

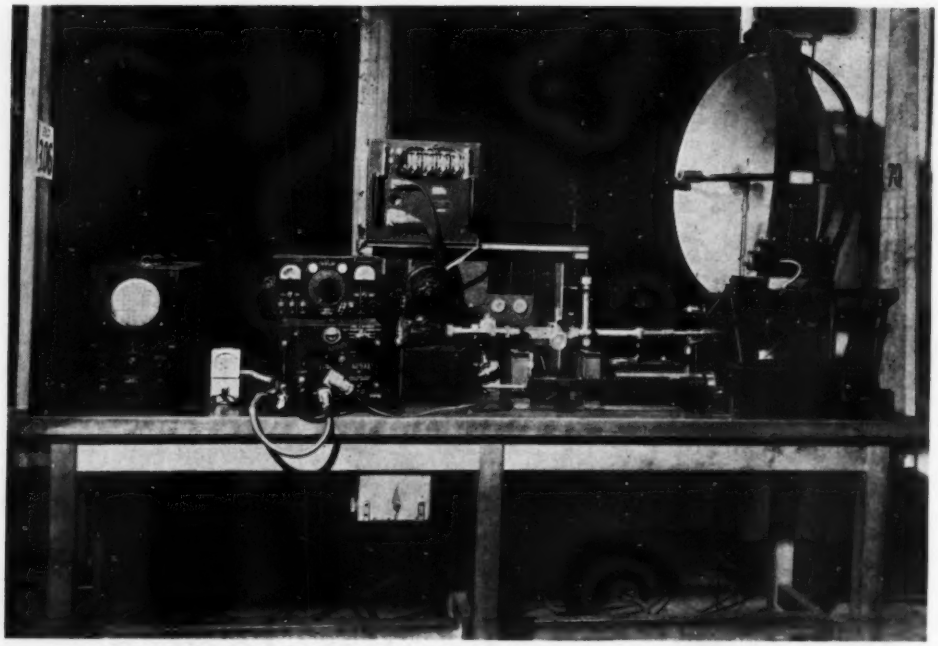
The importance of the war service rendered by the Radar School is indicated by the following passages in a letter which President Compton received recently from Vice Admiral Louis E. Denfeld, Chief of the Bureau of Naval Personnel:

> With the advent of radar and its several associated electronic implements of war, the Navy was confronted with the unprecedented problem of training thousands of officers in the specialized science of electronics.
>
> Early in 1941 when it became apparent that these electronic developments were to play a vital role in the ultimate outcome of this war, it was natural that this bureau should turn to the Massachusetts Institute of Technology for assistance in the training of technical personnel. . . .
>
> Over 4,500 officer graduates of this school have served the Navy with commendable efficiency on ships, aircraft, and at shore establishments all over the world. The efficiency and effectiveness of these officers reflect great credit to the training given at the Massachusetts Institute of Technology.
>
> On behalf of the Navy Department, I wish to express to you and to the members of your staff sincere appreciation for the tremendous task so successfully completed, the continuous cooperation and cordial relationship, all of which have been vital contributions to the successful prosecution of the present war.

In August President Compton received from Major General H. C. Ingles, Chief Signal Officer, a similar commendatory letter regarding the training which the Radar School had provided for Army personnel.

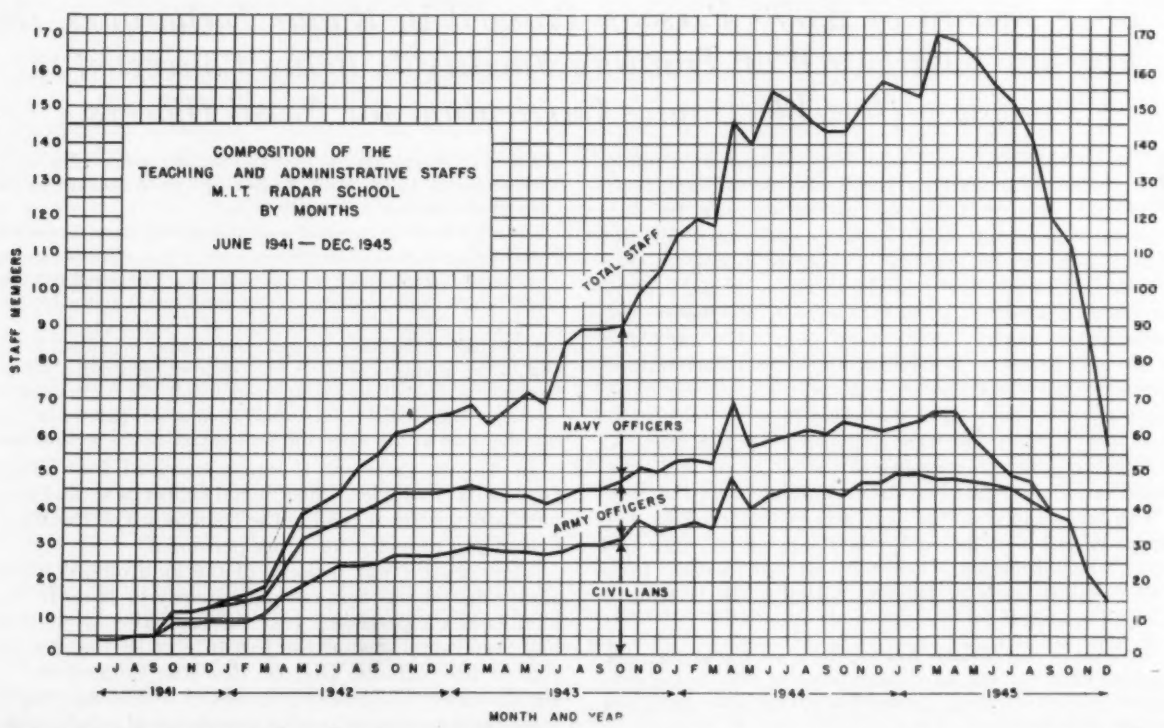
The need for war training of the kind offered at the Radar School was first recognized early in 1941. In November of the preceding year the Radiation Laboratory had been established at the Institute under the sponsorship of the National Defense Research Committee.[1] As the laboratory progressed in its efforts to develop a microwave radar system and as the importance of radar became

[1] See "Expanded Horizons," by L. A. duBridge and L. N. Ridenour, in The Review for November, 1945, p. 23.

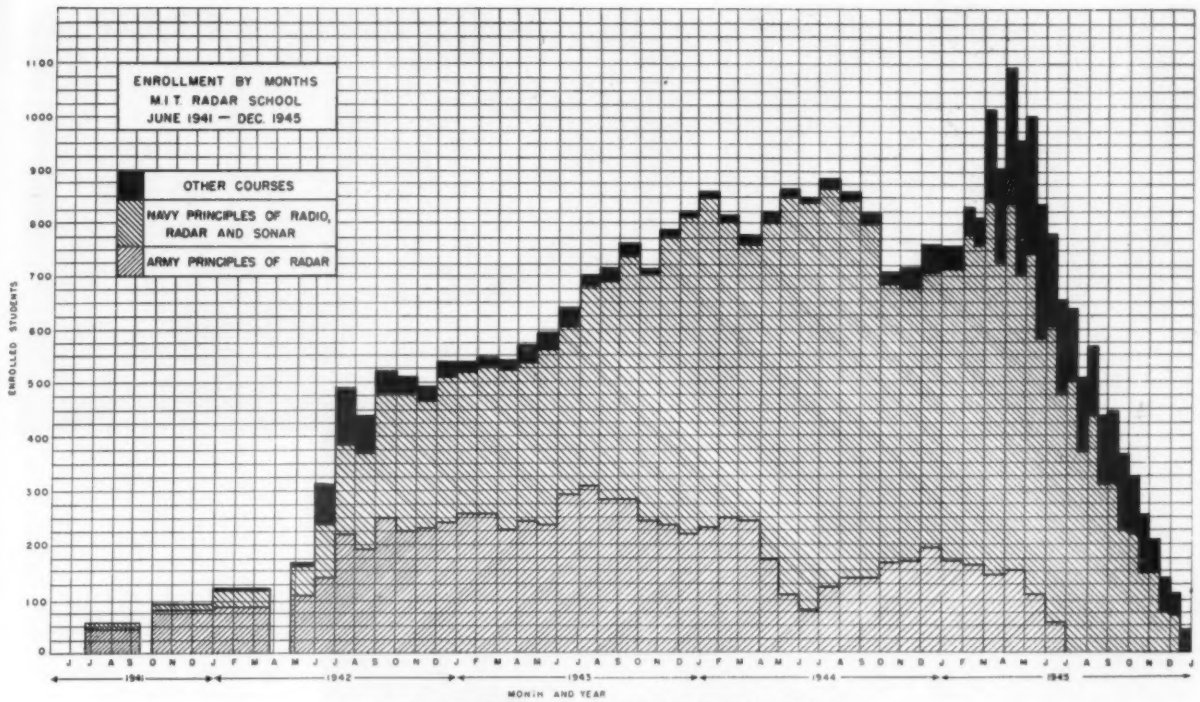


Particularly in the early phases of the Radar School, prototype microwave radar systems, assembled from development equipment of the Radiation Laboratory, were used in teaching basic radar principles.

increasingly apparent from British war experiences, it was realized that in the event of war our armed services would need many officers well trained in the basic principles and techniques of ultrahigh-frequency and microwave radar systems. In the spring of 1941, Professor Edward L. Bowles, '22, of the Department of Electrical Engineering, who was then secretary of the N.D.R.C. microwave committee, discussed this need with Dr. Compton, who agreed that the Institute should offer to provide the special radar training which the Army and Navy would probably require. The Institute was well prepared to offer such training not only because it was host to the Radiation Laboratory but also because of the considerable teaching and research experience in the ultrahigh-frequency field which members of the Department of Electrical Engineering already had.


COMPOSITION OF THE
TEACHING AND ADMINISTRATIVE STAFFS
M.I.T. RADAR SCHOOL
BY MONTHS
JUNE 1941 — DEC. 1945
TOTAL STAFF
NAVY OFFICERS
ARMY OFFICERS
CIVILIANS
STAFF MEMBERS
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1941
1942
1943
1944
1945
MONTH AND YEAR

Teaching staff of the Radar School during the war was composed of civilians, a fairly constant number of Army officers, and a widely varying number of Navy officers.



Enrollment in different courses taught at the Radar School

Accordingly, in May, 1941, Edward L. Moreland, '07, Dean of Engineering at the Institute, and Professor Bowles conferred with representatives of the Army and Navy. It was agreed that a selected group of officers should be given thorough training in the fundamentals of radar. These officers would be prepared to master future microwave radar equipment and to instruct other personnel in the principles and techniques of the art. This conference led to establishment of the training activity which later became known as the M.I.T. Radar School.

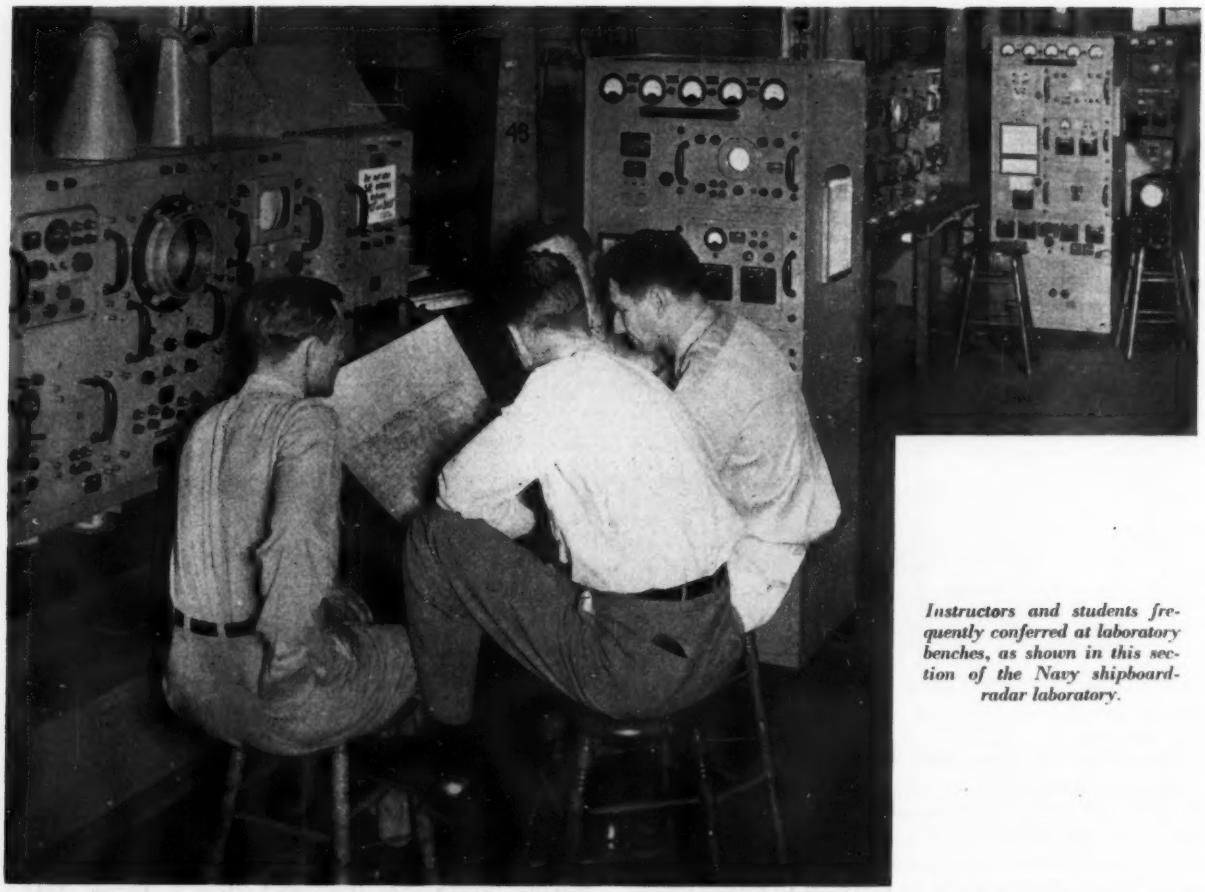
The first course began on June 23, 1941, and was attended by 44 Army officers and 14 Navy officers. This full-time course was of 12 weeks' duration and included a brief review of radio fundamentals followed by intensive instruction in the principles of radar and their specific applications in two representative systems: a microwave (10 centimeter) air-borne interceptions system, then under development in the Radiation Laboratory, and a long-wave (1.5 meter) searchlight control set, known as the SCR-268, which had been developed by the Signal Corps. Instruction on unclassified topics was given in regular Institute classrooms and in the communications laboratories. The radar instruction, which was classified "secret," was given within a heavily guarded area in Building 32, a temporary building on Vassar Street, west of the Institute's main group of structures.

In June of 1941 Harvard University offered to assist the Army and Navy by establishing special courses in electronics for members of the armed services. Conferences were held among representatives of the Army, Navy, Harvard, and the Institute, and it was agreed to establish a co-ordinated program under which officers selected for radar training at the Institute would first receive preparatory instruction at Harvard. Accordingly, a special full-time pre-radar course, dealing with nonclassified applications of electronics and radio, was established in the Harvard Graduate School of Engineering, and the first class entered on July 17, 1941. Originally of 10 weeks' duration, this course was soon lengthened to three months and later to four and five months for some groups.

Subsequently the Navy set up additional pre-radar training programs at Bowdoin College in August, 1941, and at Princeton University in June, 1943. The Harvard and Princeton pre-radar schools were continued until the summer of 1945, and the Bowdoin program was terminated soon after the end of the war. There was close liaison between the Institute Radar School and the pre-radar schools. Curriculum co-ordination conferences were held frequently, and every effort was made to give the students the best possible preparation for studying radar. The uniformity and effectiveness of the preparation given by the pre-radar schools greatly eased the task of the Radar School and was an important factor in the success of the entire training program.

Beginning with the second class, which entered in October, 1941, practically all of the Army and Navy officers who entered the Radar School were graduates of one of the pre-radar schools. Having better prepared students, the school was able to eliminate the review of radio fundamentals included in the first course and to give increased emphasis to radar principles and applications. Both the second and third classes, which started in January, 1942, received all of their training in Building 32, where the school occupied a total floor area of 9,000 square feet.

At the request of the Army and Navy early in 1942 plans were laid for a considerable expansion of the Radar School. New quarters were obtained on the upper floors and roof of the Harbor Building, an industrial type of building at 470 Atlantic Avenue, Boston; the staff was enlarged, and other essential facilities and services were provided to establish a secured and self-contained school



Instructors and students frequently conferred at laboratory benches, as shown in this section of the Navy shipboard-radar laboratory.

capable of accommodating 500 or more full-time students. In its new site, overlooking Boston Harbor and the airport, the school had ready access to many interesting radar targets. Operations at the Harbor Building started on May 4, 1942, marking the beginning of the second important period in the history of the school. Highlights of this period, as well as of the initial period of operation in Building 32 and the final period from February 1, 1944, until December 15, 1945, are summarized in Table I.

After the school moved to the Harbor Building, classes entered on the first weekday of each month, and the student population grew rapidly. The increase of personnel and the enrollment by months are shown on page 229. The enrollment exceeded 500 for many months (December, 1942, until August 15, 1945) and reached a peak of 1,094 in April, 1945.

Throughout the second period of operation the courses for Army and Navy officers were of three months' duration and comprised a common "basic course" followed by a program of special instruction for each group. The basic course covered the fundamental principles of radar and their applications in certain prototype microwave systems which had been developed by the Radiation Laboratory. After a class completed the basic course, Army and Navy officers were separated, and each group studied specific production radars currently important to its branch of the service. During the year ending May 1, 1943, the basic course was two months long. Thereafter, both the Army and Navy supplied the school with more and more standard production radars. The basic course was shortened, prototype equipment received less attention, and there was increased emphasis on service radars. During the latter half of 1943, considerable specialization was provided for Army officers of the Signal Corps, Air Forces, and Coast Artillery Corps and for Navy engineering, ordnance, and aviation officers.

The beginning of the third period of operation in February, 1944, was marked by the inauguration of completely separate courses for Army and Navy groups and by a further increase in specialization for the various service branches. During the third period, curricula were frequently revised to keep the instruction abreast of the rapidly advancing radar art. To permit adequate coverage of the large number of systems which the Navy officers had to know, it became necessary on April 1, 1944, to lengthen their courses to four months. In October the course for engineering (shipboard) officers was further extended to four and one-half months, and in January, 1945, there was a similar extension for the aviation officers.

The numerous course changes and extensions during the second and third periods of operation necessitated repeated expansions of school facilities. By March, 1944, the space occupied in the Harbor Building approximated 100,000 square feet and included all of the roof, 14th, 13th, 12th, and 10th floors, two-thirds of the 11th floor, and a portion of the second floor. By the spring of 1943 an annex had been established at Briggs Field for instruction on Army ground radar systems. In April, 1944, a second annex was opened near Kenmore Square, Boston, for

TABLE I
HIGHLIGHTS IN HISTORY OF RADAR SCHOOL

Period I — June, 1941, to April, 1942

6–23–41	First class of 58 officers started special full-time 12-week course.
7–17–41	Pre-radar training inaugurated at Harvard University.
10– 1–41	Improved 12-week course started for second class of 97 officers. Repeated for third class of 115 officers who entered 12–29–41.
	Operation in M.I.T. Building 32 (9,000 sq. ft.). Laboratory equipped with microwave prototype equipment borrowed from Radiation Laboratory.

Period II — May, 1942, to January, 1944

5– 4–42	School moved to larger quarters (36,000 sq. ft.) on roof, 14th, 13th, and 12th floors of Harbor Building at 470 Atlantic Avenue, Boston.
	New three-month course including interval of basic instruction for all students followed by separate programs for Army and Navy officers. Some specialization for Sig. C., A.A.F., C.A.C., and Navy engineering and aviation officers. Classes entered monthly. Marked trend toward increased emphasis on production models of Army and Navy radar sets.
Spring, 1943	Annex established at Briggs Field for instruction on Army ground radars. Additional space occupied on 12th floor of Harbor Building.

Period III — February, 1944, to December, 1945

2– 1–44	Separate courses established for Army and Navy with increased specialization for various branches. Prototype radars wholly replaced by service models.
3– 1–44	Additional space occupied on 10th and 11th floors of Harbor Building.
4– 1–44	Courses for all Navy officers lengthened to four months. Annex established at 19 Deerfield Street, Boston, for instruction in radar countermeasures. Instruction on Navy aviation radio begun at Harbor Building.
5– 1–44	Sonar instruction for Navy engineering officers established in new annex at M.I.T. Building 18, increasing total school floor area to approximately 120,000 sq. ft.
10– 1–44	Course for Navy engineering officers lengthened to 4½ months.
	Numerous special courses offered including 3-month course for A.A.F. Weather Wing officers, 2-month refresher courses for Navy officers, and 1-month maintenance course for Navy destroyer officers.
1– 1–45	Course for Navy aviation officers lengthened to 4½ months. Navy sonar training barge located in Charles River Basin.
6–29–45	Army war training program completed.
12–15–45	Navy war training program completed.

Period IV — January 1946

1– 1–46	New electrical engineering curriculum established for Navy officers specializing in electronics.

TABLE II
SUMMARY OF PERSONNEL TRAINED
June, 1941, to December, 1945

Course	Officers	Enlisted Men	Civilians	Total
Army, regular	2,549*	24	3	2,576
Army, special	56	3		59
Navy, regular	4,951†		7	4,958
Navy, special	695	227	82	1,004
Radiation Laboratory ‡			265	265
Total	8,251	254	357	8,862

* Includes 6 Royal Air Force and 17 Royal Canadian Air Force officers.

† Includes United States Coast Guard Reserve, United States Marine Corps Reserve, and 4 Allied officers.

‡ Radiation Laboratory staff members who completed the basic course between May, 1942, and December, 1943.

instruction in radar countermeasures, and in May a third annex was established at the Institute's Building 18 for instruction in sonar,[2] bringing the total school floor area to approximately 120,000 square feet. The final major addition to the school facilities was made in January, 1945, when a specially constructed sonar training barge was moored near the Technology Sailing Pavilion in the Charles River Basin.

The objectives of the principal courses of instruction for Army and Navy officers were fundamentally the same throughout the three periods of operation of the school, notwithstanding numerous changes in course content and shifts in emphasis. The primary objectives were always to give the student thorough instruction in the basic principles and techniques of radar and to teach him the applications of these principles and techniques in representative ultrahigh-frequency and microwave radar sets and related devices currently used in the field. Because of the phenomenally rapid development of radar and the increasing complexity and variety of the many sets produced, it was impossible to instruct the officers in the details and peculiarities of all sets which they would later encounter in the field. Thorough training of broad basic character was therefore essential.

Concentration on basic principles was particularly marked in the courses for Army officers. Although these courses did not cover radar maintenance practices, whenever suitable service sets were available in sufficient numbers they were used as teaching vehicles, with the Signal Corps, Army Air Forces, and Coast Artillery Corps groups specializing on the systems of particular importance to their respective branches. After completing their work at the Institute, practically all of the officers were assigned to Army schools for further training in the operation and maintenance of the specific types of radar sets which they were to encounter in the field.

Until the spring of 1944 many of the Navy officer graduates of the school likewise were assigned to Navy schools for a small amount of additional instruction in equipment maintenance. At that time, however, the Navy asked the Institute to add some maintenance instruction to the Radar School courses so that the officer graduates would be ready to proceed directly to their fleet and shore assignments. The courses for engineering and aviation officers were eventually lengthened to four and one-half months, and the two primary training objectives discussed above were supplemented by a third objective, namely, to give each student practice in the maintenance of equipment representative of that which he would normally encounter in the fleet.

Instructional methods at the Radar School were similar to those regularly employed in undergraduate courses at the Institute, although there was greater emphasis on laboratory work and more extensive utilization of charts, films, lantern slides, and other training aids. There were lectures, supervised study and problem periods, laboratory conferences, and examinations.

A student's daily schedule included several hours of lecture and supervised study and a three- or four-hour laboratory period. From 40 to 50 hours of instruction were scheduled each week. In addition, students were required to devote at least two evenings each week to preparation and review. For reasons of military security students and instructors were required to do all of their work within the guarded areas of the school. Classes were usually sectionalized to permit operation of laboratories during both morning and afternoon sessions and also to reduce the size of lecture groups. *(Continued on page 244)*

[2] Navy underwater sound equipment used in submarine warfare

Technology and Medicine

Modern Physical Technological Methods Initiate New Directions of Medical Research, Develop Better Instruments for Diagnosis and Therapy, and Open up New Careers

By Kurt S. Lion

HARDLY any other field of science is as misunderstood by the general public as that of medical research. Excessive dramatization is partly responsible for several popular misconceptions. Most common of these ideas is that the predominant number of advances in medicine begin with a man, sitting at a sick bed, utterly shaken by the effects of an incurable disease. Suddenly he has a new idea. He makes a few experiments, preferably on himself, which are successful. At first, no one believes in his work, but finally he is recognized and cures thousands of people.

Medical research does not follow such a course. Nor does a medical research center suddenly flourish into full bloom after a chance meeting has brought together a physician, a chemist, a physicist, and a financier who become united in their humanitarian collaboration by a burning desire to relieve the sufferings of humanity.

For the past 20 or 30 years chemistry has played an important role in medicine, whereas the participation of physics has been relatively limited. This condition is easily understandable. With the exploration of the chemical composition of and processes occurring within the body, a number of specifically acting compounds was found which could be used therapeutically. Not so in physics. The physical phenomena and forms of energy — particularly those employed in physical medicine — are mostly nonspecific, at least in the way in which they were used in the past. Another reason for the relatively small influence of physical sciences in medicine is simply that physics is too difficult. The physical phenomena in biology and medicine are for the most part so complicated that they have not yet been explored. The whole arsenal of physical research, from quantum theory to the technique of instruments of the highest sensitivity, is needed to investigate these problems. Without these powerful tools, any research in the biophysical field was formerly rather hopeless.

Already we have reached the point where a change of decided importance can be observed. The theoretical and technical means of this research are now available. The interest in, and therefore the number of articles and books about, subjects in physical medicine, biophysics, and medical physics has considerably increased of late. The war has stimulated important research in physiology as related to physical phenomena. There is much evidence of the desire to make the results of recent physical and technological investigations available for the service of biology, medicine, or public health. This tendency is manifested in the fields of electronics and instrumentation, in transportation engineering and air conditioning, in nuclear physics and, quite significantly, theoretical physics.

The introduction of physical and technological research into the medical field is very promising. Formerly, medicine had been developed on a highly empirical basis. Medical men were concerned merely with the over-all effects produced; a living organism such as a guinea pig would be treated in a specified manner, and the gross results of the treatment would be observed. The newer approach involves a quantitative study of the effects of the various physical phenomena acting upon the living organism and investigates step by step the results of these actions. Even though accurate physical measurements cannot yet be made on each and every aspect of the phenomena, the value of the approach is beyond question.

To illustrate this type of research, assume that we wish to study the medical effect of an x-ray treatment, applied to a given location of a tumor at a certain depth in the body. The treatment may be given under a great variety of conditions, using different x-ray generators, tubes, voltages, currents, filters, and distances between the generator and the subject. The biological results of such a treatment will be different in each case. But when we know enough about the absorption and scattering of x-rays in tissues and the effect of wavelengths and other physical magnitudes, we shall be able to predict the dose distribution in the body. Experimental results then become comparable, and the biological and medical results can be correlated with the physical phenomena causing them. At the same time, the number of variables involved diminishes greatly as will the number of opinions and contradictory reports so frequently encountered in medical literature.

The result of any kind of therapy is to be measured by the clinical success and the cure of the disease, of course. The process of healing a disease is, however, a consequence of a given treatment in addition to a great number of physiological and psychological processes. So long as consideration is restricted merely to the treatment and the cure, one does not know whether the patient got better because of, or in spite of, the treatment. In other words, the mere observation of the clinical end result is unsatisfactory because it is incomplete. Only that type of medical research which investigates the action of the treatment step by step will lead to the finding of natural laws which will always be valid and which, in the hands of the physician, will be a valuable guide to him.

This type of research also indicates how medical instruments should be fashioned so that better results may be obtained. For example, research on high-voltage x-rays has shown that it is possible to obtain an increase in x-ray energy in the depth of the body in such a way that the surface layers through which the beam passes are relatively little affected. This knowledge is of greatest

importance in the treatment of deep-seated tumors, and the development and production of appropriate equipment for clinical use follows as a logical consequence of such research. This single example is sufficient to show that physical and technological research may brilliantly complement clinical observation in furnishing the guiding principles for supplying medical men with new equipment.

Diagnostic Applications

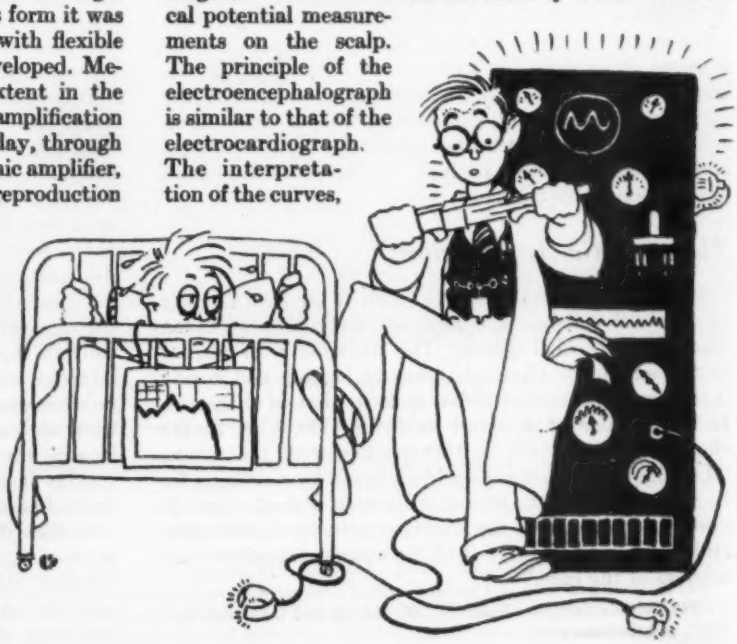
A great need for research and development may be anticipated in the field of physical diagnostic methods and instruments, and here again technological developments are able to make substantial contributions to medicine. One of the most commonly used instruments in the doctor's office, the stethoscope, belongs in the category of such physical diagnostic tools, and its development illustrates the benefits which modern technology can bring to the medical sciences.

When the stethoscope was first introduced into practical use in 1819 by René Laënnec, it consisted of a rigid hollow tube with enlarged end pieces. In this form it was used for a long time until the stethoscope with flexible tubing and a membrane at one end was developed. Mechanical resonance is employed to some extent in the flexible tubing stethoscope and provides some amplification over a narrow but useful frequency band. Today, through the use of a microphone and a suitable electronic amplifier, the electronic stethoscope makes possible the reproduction of the sounds of heartbeats for large audiences. At the same time, the instrument is able to record all aspects of systolic and diastolic contractions or, using filters, to select for special study any range of the frequency components of heartbeats. At present, the electronic stethoscope is used primarily for research, but there are other electronic instruments which have been adopted in standard routine examinations in medical practice.

Research on physical diagnostic methods and the development of instruments required for diagnosis are particularly promising at present through the use of electronic means. The complete lack of inertia in electronic equipment (at least so far as concerns the biological process to be measured), the ability to amplify, and the negligible amount of input power required to control electronic devices are, in part, reasons for the general anticipation of such a development. But biological considerations also contribute good reasons for the adoption of electronic equipment. Of these reasons, one of the foremost is that minute voltages, called action potentials, are produced within the body as a result of biological activity of the heart, brain, or nerves, for example. The amplification, detection, and analysis of these action potentials has opened up new fields of diagnosis which have reached their most advanced developments in the fields of electrocardiography and electroencephalography. Moreover, it has been found that the electrical characteristics of the skin may be used for diagnostic purposes, and here again electronic equipment is called upon to play its important role.

In electrocardiography the action potentials generated in the body as the result of the beating of the heart are obtained from electrodes placed on the arms, legs, or chest of the patient. These minute voltages are then amplified and recorded. A deviation of the recorded curves from the normal pattern indicates a pathological alteration of the heart activity. Since the patterns for different diseases are known, a reliable differential diagnosis is usually possible. It has also been proposed to use these action potentials for therapeutic purposes, as, for example, resuscitation or the treatment of cardiovascular diseases. Pick-up electrodes, from which the action potentials are obtained, are attached to the patient. After suitable amplification these potentials are reapplied to the patient by means of another pair of electrodes. By designing the amplifier for proper phase shift or delay of signals, it may be possible to stimulate the activity of the heart in its own rhythm. In this technique the heart is used as a self-excited oscillator. As yet, little is known about the results obtained with this method.

The electrical activity of the brain is recorded by means of the electroencephalograph, which makes possible the diagnosis of certain mental disorders by means of electrical potential measurements on the scalp. The principle of the electroencephalograph is similar to that of the electrocardiograph. The interpretation of the curves,



which are naturally much more complex than those of the electrocardiograph, is, however, sometimes difficult. Considering the very complicated processes of the brain activity, we would expect this, but the difficulty is a particular challenge to obtain more and better information by the use of improved equipment. With this method it is now possible to determine the location of a brain tumor (sometimes very important in brain surgery), and it may become feasible to localize or co-ordinate certain parts of the brain with some mental or physical anomalies. A considerable increase in the sensitivity of the instruments used in electroencephalography is not possible, however. The magnitude of brain action potentials is close to the noise level which it is impossible to overcome.

It is to be expected that further research on electric nerve action potentials in connection with other organs, glands, and so on, will evolve diagnostic methods which are perhaps of even greater importance in general medicine or in psychiatry than the ones we already have. The difficulties are great; what we measure is largely a superimposition of many different electrical signals. Sometimes the development of special experimental techniques is required to eliminate those signals which are not desired and to record undistorted the signals characteristic of the process under study. One difficulty here is the lack of a proper explanation of the fundamental process of propagation of nerve action potentials. The velocity with which an impulse travels along a nerve is of the order of one meter a second. This velocity is too fast for propagation to be achieved by purely chemical means; it is too slow to be the result of a purely electrical phenomenon.

The problem of physical diagnosis is frequently that of getting some information about processes going on inside the body from measurements on the body surface. Besides mechanical, thermal, or optical properties of the skin, its electrical properties can also be used diagnostically. From simple electrical resistance measurements of the skin one can get indications of the activity of the sympathetic nervous system and of emotional reactions of the person under observation. An instrument used for this purpose is known in medicine as a psycho-galvanic reflex meter and has attained wide publicity as the lie detector. It is very likely that this instrument, in the hands of an experienced psychologist, can uncover the deeper cause of many diseases and, perhaps, can open up a new physical experimental approach to psychological and neurological studies which, in the past, have been based solely upon theory.

Therapeutic Applications

Many persons also expect the field of physical therapy to show a development as rapid as that which has taken place in physical diagnosis. The situation with respect to the search for physical means of healing and curing is, however, somewhat different from that of diagnosis. In his popular book about medicine[1] Dr. Carl Binger characterizes research in therapeutics with the words, "Like happiness, a cure is seldom found by searching for it. Some cures are the logical outgrowth of deep scientific understanding, others are stumbled upon by accident and still others have grown out of the ancient experience and wisdom of the race."

[1] *The Doctor's Job* (New York: W. W. Norton and Company, Inc., 1945), p. 149.

Physical medicine, in particular, is the outgrowth of experience. Apparently heat and cold, air and water, and the beneficial influence of the sun's radiation have been used to fight diseases since the earliest times of humanity. The powerful effect of radiation therapy is known to everyone who has used this treatment in too large dosages on the beach; painful sunburn is the vehement reaction of the body. On the other hand, lack of the sun's radiation can cause severe diseases, since the formation of important compounds in the skin is due to photosynthetic processes and requires the presence of radiation of the appropriate wavelength.

The wavelengths of light which are of greatest importance in medicine are located in the ultraviolet portion of the spectrum. In general, three different ranges of ultraviolet radiation may be distinguished. The range of from 315 to 400 millimicrons has the power to penetrate the skin to an appreciable extent and is used in the treatment of some diseases, for instance, lupus. A second range of ultraviolet radiation, between 280 and 315 millimicrons, produces erythema of the human skin and is applied in the treatment of rachitis (rickets). The range of wavelengths shorter than 280 millimicrons has a particular germicidal effect. The primary effect of ultraviolet rays on cells or on proteins is still a difficult problem, especially since it is expected that the energy of a single photon of the radiation must have some relation to the binding energies within the structure of proteins.

Such specific effects are not to be expected in the infrared part of the spectrum. The effect of infrared treatment consists more of superficial heat, which may increase the flow of blood through the capillaries, relax muscle spasms, or produce locally increased metabolism. Frequently one finds the opinion expressed that infrared rays are able to penetrate into the depths of the body, but this is not so. Particularly those lamps used in infrared therapy which operate at low-color temperature (room heaters, for example) produce a radiation of which not more than a fraction of 1 per cent enters the skin. The waves longer than 1.4 microns are absorbed by oxyhemoglobin. Of course, this does not mean that infrared treatments are ineffective but rather that beneficial effects occur only in certain regions of the body.

If heat is to be applied into the deeper regions of the body, the techniques of diathermy and short-wave diathermy are more appropriate. Short-wave dielectric and induction heating have been used in medicine for more than a decade and have been employed by industry on a large scale for only a few years. Industrial research in this field has recently been so successful, however, that its results can now be used for medical applications. The development of ultrahigh-frequency equipment during the war will enable us to use electromagnetic waves medically in the range between very short radio waves and infrared waves. Theoretical considerations and actual measurements made on short-wave radiation fields show that, at least to some extent, it is certainly feasible to localize the effects of electromagnetic waves to certain regions inside the body by focusing the waves on the desired area or organ.

Unlike direct-current or low-frequency electric impulses, high-frequency voltages and currents do not produce electric shocks. At radio frequencies, several amperes can be sent through the body without any sensation other than that of (*Continued on page 256*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Housewarming

ON JANUARY 6 more than 200 persons — members of the Faculty and administrative staff, their wives, members of the M.I.T. Women's Association, and friends of Technology's coeds — attended the housewarming of the first dormitory for women students to be operated at the Institute. In the attractive residence which was opened for occupancy at the beginning of the new term on November 5, the guests found a homelike, uninstitutional atmosphere, carefully planned and designed to appeal to the young women students.

The purpose of the house is to provide a pleasant, economical place in which some of the Institute's increasing number of women students may live in an environment conducive to study and personal development. The Residence Advisory Board,* appointed by President Compton to develop plans for the new unit, believes that "experience in gracious living is an important part of a woman's preparation for effective personal and professional life and has made every effort to provide a suitable framework for such experience. All students accepted for residence in the house are expected to contribute to the fulfillment of these purposes. . . ."

The women students' house, purchased last summer by the Institute, is a four-story dwelling at 120 Bay State Road, Boston, about a mile from the main buildings of

*Temporary members of the Residence Advisory Board include Mrs. Karl T. Compton, Chairman, Mrs. N. M. Sage, '13, Mrs. M. P. Horwood, '19, Miss Florence W. Stiles, '22, adviser to women students, Miss Margaret Whitcomb, '39, Miss Joan Rothwell, 6–45, Miss Mary Sullivan, 6–45, and Mrs. L. F. Hamilton.

Westgate Development. *In an attempt to alleviate the housing shortage for students in Cambridge, the Institute has taken the lead among colleges in providing housing facilities for the relatively large group of married students who are expected to return from their wartime activities for additional education at Technology. The program (announced on page 45 of The Review for November) was well on its way toward completion when this picture was taken late in December.*

In the Institute's program to provide homes for 100 married couples, ultimately there will be 50 houses containing one bedroom and 50 houses containing two bedrooms. The houses, arranged in single and twin units, are similar to small apartments but have the privacy of a house and the additional advantage that each house has its own plot of land. Both single- and double-bedroom houses contain combined living rooms and dining rooms, separate kitchens, and ample closet space. After completion and landscaping of the project, there will be adequate provisions for parking space for automobiles.

These houses are being built on the 10-acre plot on Institute property in Cambridge, a few blocks west of Massachusetts Avenue, between Memorial Drive and Vassar Street. The Westgate project is designed to provide facilities for a period of about five years and is aimed primarily to accommodate the large postwar enrollment of the next few years. In addition to housing veterans, Westgate will serve the added purpose of a study of the possibilities for future permanent housing for married students, research assistants, and young instructors.

Joseph J. Snyder, who took office as assistant treasurer of the Institute on January 1

the Institute, and may be reached conveniently by subway and surface lines. The house has been completely redecorated and furnished under the guidance of the enthusiastic members of the Residence Advisory Board, who faced the problem of equipping an entire housing unit under the restrictions of wartime shortages. In times like these, when it is difficult to obtain building materials, furnishings, and textiles, the committee did an excellent job in having the house in readiness for occupancy when the new term began on November 5.

The social rooms on the first floor include a reception hall, living room, dining room, and kitchen. There are four large double bedrooms with single beds, two smaller double bedrooms with double-deck beds, and two single rooms. Off the garden at ground level are a study hall and a completely outfitted laundry. Equipment for each occupant includes bed, mattress, pillow, three blankets, bed linen and towels, chest of drawers and mirror, desk and chair, bookcase, rug, and desk lamp.

Although the students get their own breakfast, a competent cook prepares dinner. The cost of the room and board has been kept as low as is consistent with wholesome living.

Mrs. Margaret Alvord, a graduate of the Boston Conservatory of Music and mother of four grown children, is housemother. With its piano, her room is a popular place for the students to gather after dinner to relax and listen to good music. A housewarming gift of a set of symphony records accentuates the need for a radio-phonograph for the house.

The new dormitory accommodates 14 of the Institute's 90 women students (70 of whom are candidates for degrees, the others being part-time students). In a sense, this unit is experimental, since the experience gained in its operation will undoubtedly play a major role when the time comes for building larger facilities for women students at Technology. Student self-government is in force. Each student cares for her own room and may reduce living expenses by helping with the cleaning of the general rooms of the house and by waiting on table.

The almost immediate amalgamation of a variety of unknown human beings into a commendable unity has produced among the first group of residents a harmony and high degree of co-operation which give character to the house and augurs well indeed for its future.

Assistant Treasurer

THE appointment of Joseph J. Snyder, Vice-president of the Railway and Light Securities Company of Boston and chairman of the board of the Michigan Seamless Tube Company, as assistant treasurer of the Institute has been announced by President Compton.

Mr. Snyder will be associated with Mr. Ford, Treasurer, who first joined the administrative staff of the Institute in 1914.

The Institute's assistant treasurer brings to his new post the advantages of wide experience in management and finance. His business affiliations include partnership in the Colonial Investment and Management Associates of Boston; he was vice-president of the Investment Service Corporation from 1934 to 1945. He has been financial adviser to Edwin S. Webster since 1934.

Mr. Snyder is the son of Mr. and Mrs. Paul J. Snyder of Findlay, Ohio, where he was born in 1907. He was graduated from the Carnegie Institute of Technology with the degree of bachelor of science in 1931 and from the Graduate School of Business Administration, Harvard University, with the degree of master of business administration in 1934. From 1943 to 1944 he carried on special graduate studies at the Institute. From 1944 to 1945 he was secretary of the budget committee and associate head of the Office of Business Administration of the Radiation Laboratory at the Institute.

Mr. Snyder was president of the Harvard Business School Alumni Association from 1943 to 1944. He is a member of the Detroit Club, and his fraternity is Beta Theta Pi. In 1937 he was married to Miss Helen T. Colburn of Wellesley. They have three children, and their home is in Weston, Mass.

Science Lectures

THE Society of Arts popular science lectures, discontinued during the war, have been resumed at the Institute in a winter series of Sunday afternoon talks, which began on December 16. The first lecture, "Microwaves in Radar," given by Ivan A. Getting, '33, Associate Professor of Electrical Engineering, was supplemented by demonstrations showing the characteristics of extremely short radio waves and their applications to radar.

The second lecture, on January 20, by John G. Trump, '33, Associate Professor of Electrical Engineering, en-

titled "The Acceleration of Electrons and Positive Ions by High Constant Potentials," illustrated the electrostatic method of generating a potential of several million volts for the acceleration of charged particles.

On March 3, Francis O. Schmitt, Head of the Institute's Department of Biology, will discuss "The Electron Microscope in Biological and Medical Research" and demonstrate the use of the electron microscope. Electron stains, surface replicas, stereoscopic micrographs, and electron shadowgraphs will be discussed in dealing with the techniques of electron microscopy.

The final lecture of the winter series will be given on March 24 by Gordon S. Brown, '31, Associate Professor of Electrical Engineering. Dr. Brown will discuss "The Servomechanism — Man's Mechanical Robot." The use and behavior of automatic control devices will be treated in a popular manner.

Appointed

CAPTAIN WILLIAM H. BURACKER, '30, U.S.N., has succeeded Captain Roswell H. Blair, U.S.N. (Retired) as professor of naval science and commanding officer of the Navy training schools at the Institute, with additional duty in connection with the curricula of the Navy postgraduate students.

Captain Buracker was graduated from the United States Naval Academy in 1919. In 1922 he was assigned to the Pensacola Naval Air Station for flight training and since then has performed duties both ashore and afloat as a member of the Naval Aeronautical Organization.

In 1928 Captain Buracker was assigned the postgraduate course in aeronautical engineering, which was completed at the Institute in 1930 when he was awarded his master's degree.

At the beginning of the war he was attached to the staff of Admiral Halsey as operations officer of a carrier task force in the Pacific. With Admiral Halsey he conducted the original carrier raids in the Pacific. including operations against the Marshall Islands, Wake, and Marcus. It was this task force which carried General Doolittle's aircraft for the first attack on Tokyo in the spring of 1942.

After the battle of Midway, Captain Buracker returned to this country to take command of the Naval Air Station at Pensacola. During the summer and fall of 1943 he studied in the first class of the Army and Navy Staff College with headquarters in Washington. Upon his graduation in October, 1943, he joined the staff of Admiral Nimitz as fleet aviation officer. Early in 1944 Captain Buracker was given command of the light carrier *Princeton* and served on her until October 24 of that year, when the ship was lost as a result of damage by Japanese aircraft during the Battle of Leyte Gulf. The *Princeton* operated as a unit of the fast carrier task forces, so-called Task Force 38 and 58, in actions against the Marshalls, the Marianas, Hollandia, the Ryukyus, Formosa, the Palaus, and the Philippines, participating in practically all actions in the Pacific during the period of the command without damage until the day the ship was lost.

Early in January, 1945, Captain Buracker was assigned to the staff of the Army and Navy Staff College in Washington and remained there until assuming his present duties at the Institute.

Captain William H. Buracker, '30, U.S.N., Professor of Naval Science and commanding officer of Navy training schools at the Institute

Sedgwick Laboratories of Sanitary Science

AS a consequence of the anticipated housing and construction engineering program to meet needs which are already acute, the Institute has made considerable enlargement during the past year in its program of sanitary engineering. A new program of instruction in sanitary science in the Department of Civil and Sanitary Engineering has been designed to meet the demand for engineers well trained in sanitary engineering and public health and to permit advanced students to specialize in sanitary science. Considerably greater emphasis than heretofore is placed on graduate instruction and research in the chemical and bacteriological aspects of sanitary engineering. At the same time, civil engineering students will be able to take more subjects in sanitary engineering.

To achieve the expanded program in sanitary engineering, the staff has been enlarged to include three men of professorial rank. In addition, new laboratories are being completed to permit members of the sanitary engineering staff to carry out important teaching and research work in various phases of sanitary engineering and public health. The program now being completed will enable the Institute to assume a leading position in the training of sanitary engineers with a good background in the sanitary sciences and public health. In addition, the revised curriculum will permit graduate students interested in san-

itary engineering to specialize in design, operational, or environmental phases of sanitary engineering and public health.

The Executive Committee has decided that the Sedgwick Fund may be used for laboratories to be known as the William Thompson Sedgwick Laboratories of Sanitary Science in honor of Professor Sedgwick, who was a pioneer in sanitary science and public health at the Institute. Professor Sedgwick is remembered with reverence by many graduates, particularly those of Courses VII and XI, because of his great ability as a teacher of sanitary science and public health.

Space has been allotted in the basement of Building 1, and construction of the new laboratories is now under way. The Sedgwick Laboratories will include: a laboratory of sanitary engineering to provide for illustrating principles of water and sewage treatment processed by laboratory scale units; a laboratory of sanitary chemistry for laboratory exercises essential to the teaching of sanitary chemistry and chemical analysis of water and sewage; a research laboratory for problems in water, sewage, and industrial waste treatments; and a laboratory of sanitary bacteriology for instruction and research in the applications of bacteriology to sanitation and public health.

The new program will be carried out by William E. Stanley, Professor of Sanitary Engineering, in charge of the division of sanitary engineering, Murray P. Horwood, '16, Professor of Sanitary Science, and Clair N. Sawyer, Associate Professor of Sanitary Chemistry. Professor Stanley will teach theory, practice, and design of water supply, sewerage, and water and sewage treatment; Dr. Horwood will teach sanitary bacteriology, principles of sanitary science, environmental sanitation, and public health administrative practices; and Dr. Sawyer will teach sanitary chemistry, chemical analysis of water and sewage, and sanitary engineering laboratory. Each of these men has had extensive professional experience in the fields of sanitary science.

Professor Stanley received the degree of bachelor of science in civil engineering from Kansas State College in 1912 and the degree of civil engineer from Purdue University in 1916. After a year of civil engineering experience he spent four years as instructor in hydraulics in the department of civil engineering at Purdue, during which time he spent the summers in professional engineering work in the Middle West. During World War I he was a captain in the Corps of Engineers and constructed hospitals in France. From 1919 to 1936 he associated with the firm of Pearse, Greeley and Hansen in Chicago as a consulting engineer on sanitary and hydraulic problems. He then spent five years at Cornell University as professor of sanitary engineering. During World War II as chief, sewerage and incineration, construction division, War Department, he was in charge of the design of sewerage works for camps and ordnance plants, and as major in the Corps of Engineers he served as water supply officer and later as chief of the construction branch, Headquarters Service of Supply, of the North African theater of operations. He came to the Institute in April, 1944.

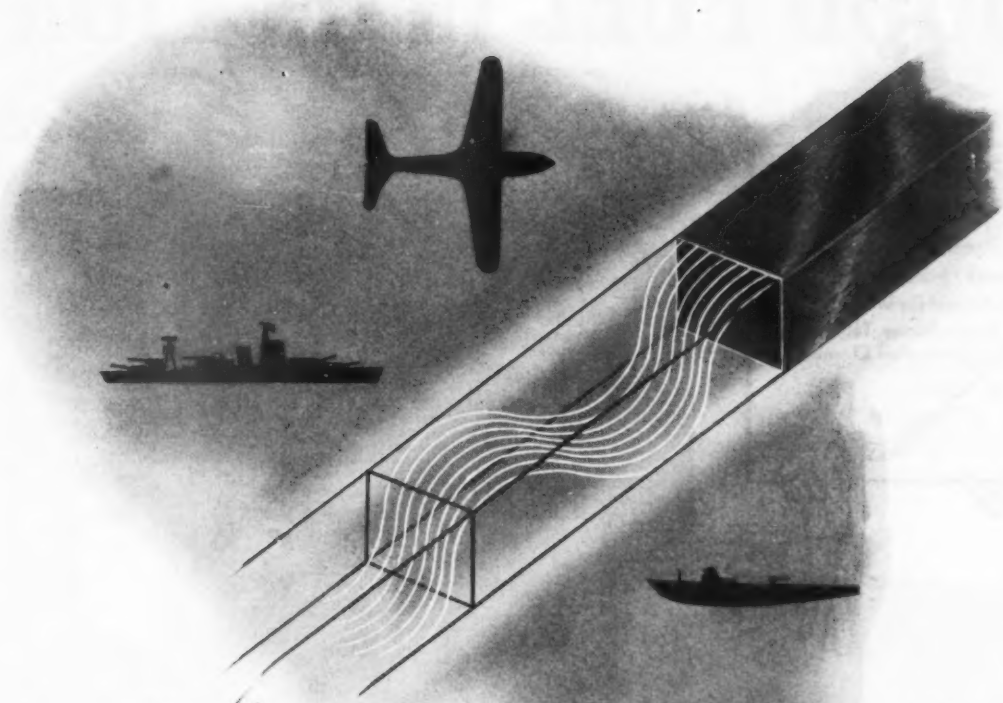
Dr. Horwood received the degree of bachelor of science from the College of the City of New York in 1913 and the degrees of master of science and doctor of philosophy in 1916 and 1921, respectively, from the Institute, where he was associated with the Department of Biology and Public Health from 1916 to 1944. In addition, he was instructor in sanitary and public health bacteriology at Wellesley College in 1917 and 1918, was in charge of bacteriology and public health at Boston University Medical School from 1919 to 1921, and for the following five years was in charge of public health at Tufts Medical College. Dr. Horwood has had varied professional experience since 1913, including his work as director of the Institute's food sanitation service (see The Review for November).

Dr. Sawyer received the degree of bachelor of science in chemistry in 1930 from the University of Wisconsin, where he remained until 1936 as instructor in chemistry. In that year he was awarded the master's degree from the University of Colorado. At the University of Wisconsin, from which he received the degree of doctor of philosophy in 1938, Dr. Sawyer was research assistant in the department of sanitary engineering from 1936 to 1938 and from 1938 to 1940 was postdoctorate fellow in the same department. From 1940 to 1942 he was assistant professor of sanitary chemistry and biology at New York University and from 1942 to 1944 was director of the lake fertilization and pollution survey at Madison, Wisc. Before taking up his duties at the Institute, Dr. Sawyer spent a year as special investigator in the operation of the Sioux Falls sewage plant for the South Dakota State Board of Health.

The Course in Sanitary Engineering was established at the Institute in 1891 and was operated on both undergraduate and graduate level as Course XI until February, 1944, when the undergraduate work was replaced by a group of elective sanitary engineering subjects in Course I, Civil Engineering. The educational program in sanitary engineering now includes undergraduate subjects as part of the Course in Civil Engineering and graduate subjects in sanitary engineering as Course XI. Those subjects which may be taken in the junior and senior years by students in the Department of Civil and Sanitary Engineering provide a limited training in sanitary engineering which should be highly useful to men intending to practice in those fields.

Twelve special subjects presently offered as graduate electives in Course XI for the training of sanitary engineers may be grouped into three categories: theory, design, and engineering practice; operational phases of sanitary facilities and stream sanitation; and environmental sanitation and public health. It is recommended that six specific subjects be required for students studying for the master's degree in Sanitary Engineering. These topics represent about one-half of the required credit hours. In addition, each student may select further subjects as he chooses so that if he wishes, he may specialize in design and engineering, in plant operation, or in environmental sanitation and public health.

The Institute has achieved a distinguished place in sanitary engineering because of the fundamental research performed in its sanitary laboratories. In the postwar period, considerable emphasis will be placed on the role of sanitation in promoting public health, and it will be necessary to expand the investigations in the broad field of sanitary engineering and sanitary science. The new Sedgwick Laboratories, properly integrated and staffed, will enable the Institute to continue to make important contributions in sanitation and public health.



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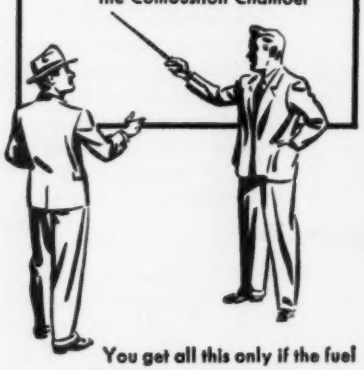

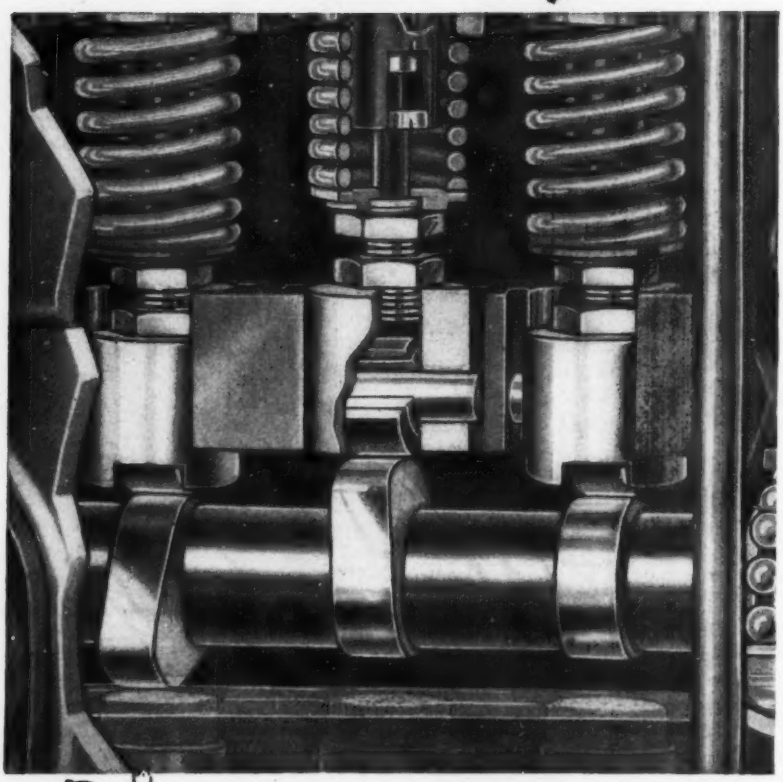

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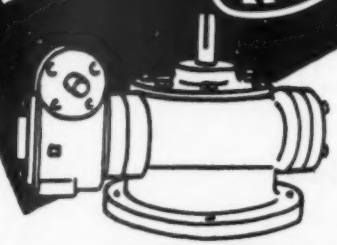

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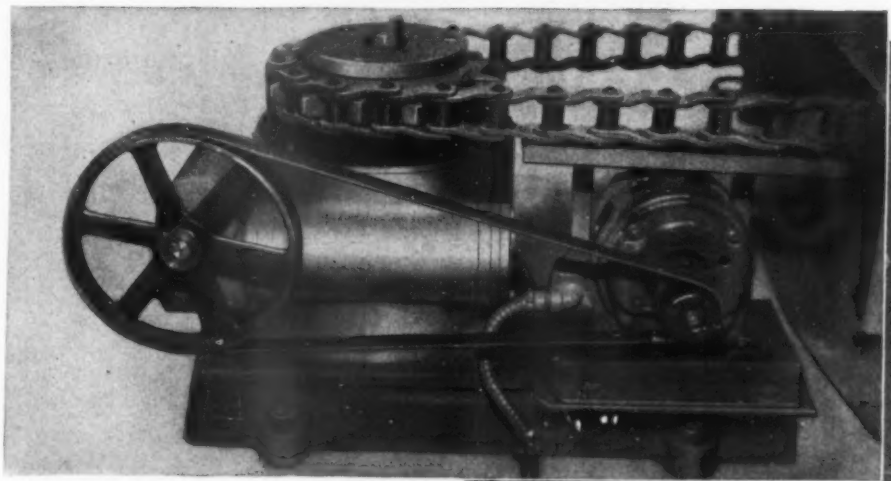

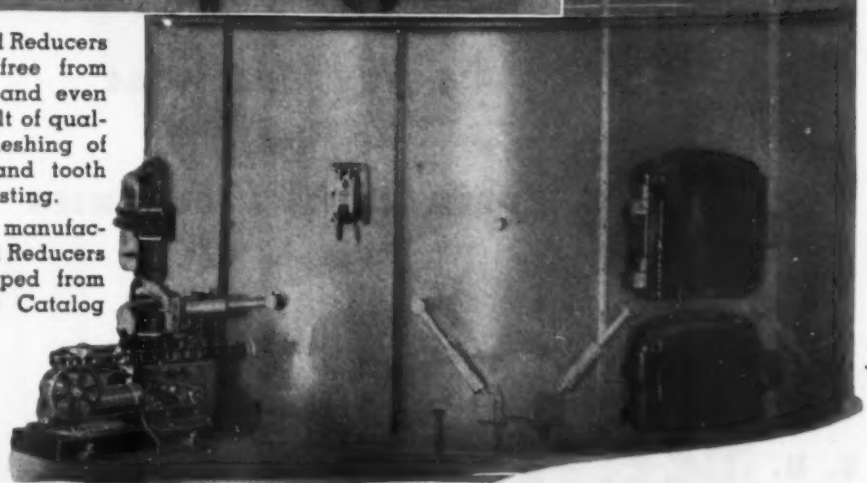

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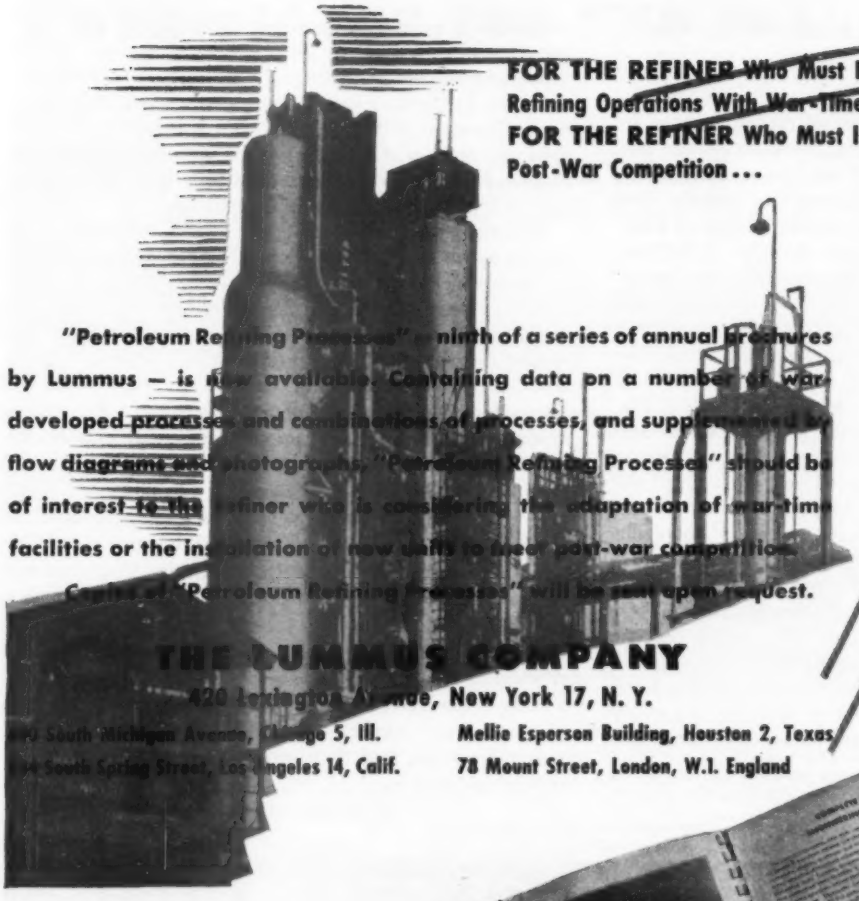

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TECHNOLOGY'S RADAR SCHOOL

(*Continued from page 231*)

One of the more important training aids used at the school was the textbook *Principles of Radar*, written by members of the teaching staff.[3] This book covers the fundamental principles on which all modern radar systems operate and was used extensively from the time the first preliminary copies became available in the fall of 1943. Other important training aids were the sets of instructional drawings which the staff prepared for every important radar system used at the school. These drawings were produced in accordance with locally developed standards, and each set included one or more functional block diagrams showing the relationships of the major components of the system and a number of detailed schematic diagrams prominently outlining principal signal paths and showing the connections of all auxiliary circuits. Notes on the diagrams indicated parameter values, operating voltages, tube types, part numbers, locations of test points, essential waveforms, and other data necessary for teaching the operation and maintenance of the system. Because of their distinctive style, these drawings were much more suitable for training purposes than the usual manufacturers' wiring diagrams. Information required for the preparation of drawings was obtained from the manufacturer and by close inspection of actual equipment. Each student was issued a complete set of drawings for every system studied. The instructional drawings were used extensively in classrooms and laboratories and aided greatly in tying together all of the teaching on a system. Upon graduation, students were permitted to keep their drawings for further use as field maintenance aids. Thousands of copies of the Radar School drawings reached the field and were widely used, particularly during the early stages of the war when manufacturers' instruction books were scarce and occasionally inaccurate.

Laboratory instruction at the school emphasized the proper use of standard measuring instruments and practical procedures for checking circuit operation. Taking data on prepared setups was avoided, and students were often required to select and arrange apparatus for particular measurements. During the third period of operation many experiments in the Navy courses stressed procedures for obtaining peak performance of a radar system, faultfinding, and preventive maintenance. Students were given printed directions and references for each experiment well in advance of the scheduled period and were required to make adequate preparations. All students were closely supervised, and, whenever possible, schedules were arranged so that no more than two men were assigned to a setup at one time. Report writing was minimized, and eventually laboratory grades were based largely on the results of individual practical examinations. A high degree of co-ordination between laboratory and lecture instruction was achieved through the use of multiple setups and careful scheduling, through the instructional drawings, and through rotation and close supervision of instructors.

(*Continued on page 246*)

[3] Originally confidential, this book is now unclassified. The second edition will soon be published by the McGraw-Hill Book Company in collaboration with the Technology Press.

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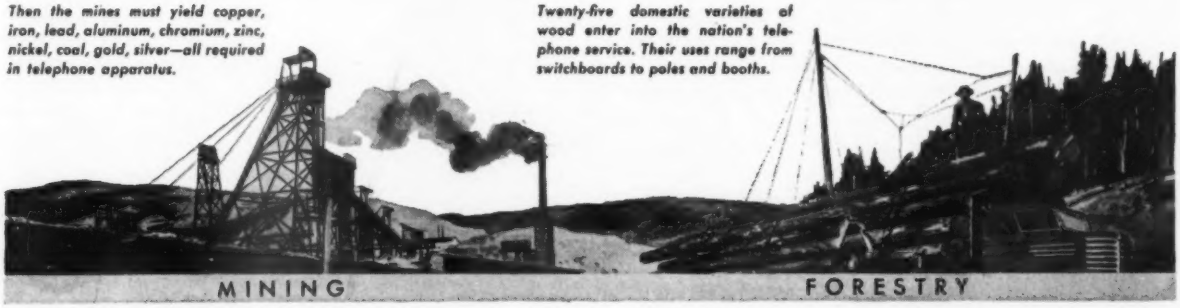
IMPORTING FARMING

Then the mines must yield copper, iron, lead, aluminum, chromium, zinc, nickel, coal, gold, silver—all required in telephone apparatus.

Twenty-five domestic varieties of wood enter into the nation's telephone service. Their uses range from switchboards to poles and booths.

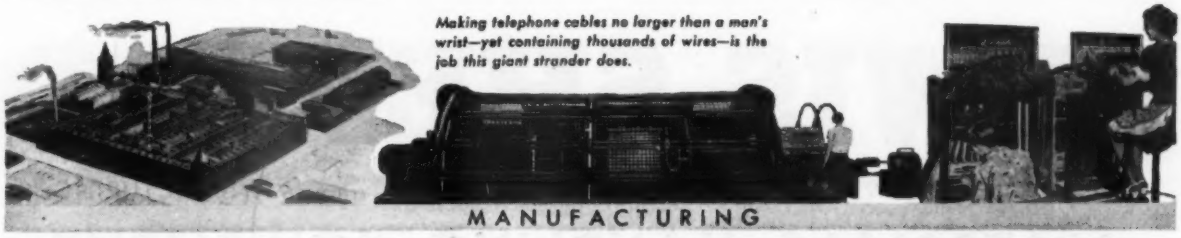


MINING FORESTRY

Raw materials must be brought together in Western Electric plants, where skilled workers and marvelous machines turn them into vast quantities of complex apparatus.

Wiring an intricate switchboard—through which your voice will go—calls for skilled hands. Remember that switchboards and cable are just two of thousands of items you use when you telephone.

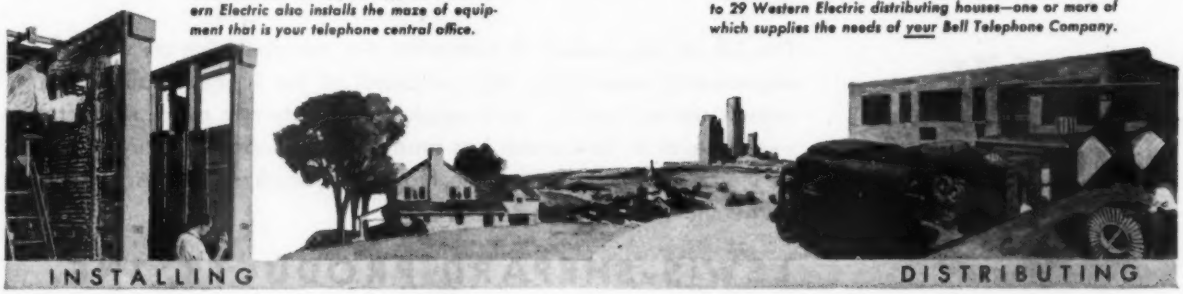
Making telephone cables no larger than a man's wrist—yet containing thousands of wires—is the job this giant strander does.



MANUFACTURING

In addition to making the apparatus, Western Electric also installs the maze of equipment that is your telephone central office.

Telephones, wire, cable and countless other products go out to 29 Western Electric distributing houses—one or more of which supplies the needs of your Bell Telephone Company.



INSTALLING DISTRIBUTING

As supply unit of the Bell Telephone System, Western Electric has one of industry's most complex jobs.

Today we are working full speed ahead on equipment not only to meet immediate telephone needs, but also to carry out the Bell System's $2,000,000,000 post-war construction program.

This vast program promises a record in peacetime production at Western Electric—with a level of employment higher than in the years just before the war—and better-than-ever telephone service for you.

Western Electric

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PURCHASER
DISTRIBUTOR
INSTALLER *of Central Office Equipment*
FOR THE BELL TELEPHONE SYSTEM

Buy Victory Bonds —and keep them!

TECHNOLOGY'S RADAR SCHOOL

(*Continued from page 244*)

During the early months of operation there were critical shortages of certain items of laboratory equipment, but later the school was well supplied with apparatus, especially during the third period of operation when Army and Navy radars and related test sets were being manufactured in great quantities. By the fall of 1944 the Navy had installed in the school laboratories one or more radar sets of nearly every type currently used by the fleet. These installations were kept up-to-date by making the usual field changes and were replaced by newer models when they became obsolete.

The full-time three-, four-, and four-and-one-half-month courses for Army and Navy officers were by far the most important activities of the Radar School. Considerable staff effort, however, was devoted to various short, special programs which were offered from time to time to fill specific needs of the services. Many of these special courses were arranged on very short notice. Some were offered only once. Others, which were repeated a number of times, included a 12-week course on special Navy air-borne electronic equipment, a two-month refresher course for Navy officers returned from fleet duty, a two-month advanced sonar course, a six-day course on maintenance of a new shipboard fire-control radar, and a six-day course for civilian scientists from the Office of Scientific Research and Development. In addition to these courses, the school also offered three subjects in radar included in M.I.T. graduate curricula which were arranged for selected officers from the Navy's Postgraduate School and the Army Air Forces. The total monthly enrollment in the special courses is shown by the chart on page 229. A summary of total personnel trained in both special and regular courses appears in Table II.

The teaching staff of the Radar School included civilians and Army and Navy officers. The composition and growth of the teaching and administrative staffs are shown on page 228. Owing to the character and variety of the courses offered and the need for detailed planning and supervision, it was necessary to maintain a low over-all ratio of students to instructors. The civilian instructors included members of the Department of Electrical Engineering,[4] staff members on leave from other colleges, engineers and physicists recruited from industry, and a number of recent Institute graduates. Almost all of the Army and Navy officers were Radar School graduates whose services had been requested by the Institute. Many of the officers had had radar field experience before

[4] Present members of the Department of Electrical Engineering who served were: Professor C. E. Tucker, '18; W. L. Barrow, '29, Associate Professor of Electrical Communications; W. H. Radford, '32, Associate Professor of Electrical Communications; M. S. McIlroy, '41, Assistant Professor of Electrical Engineering; G. T. Coate, '42, Assistant Professor of Engineering Electronics; H. J. Zimmermann, '42, assistant; L. W. Evans, '43, instructor; J. P. Chisholm, 2–44, assistant; L. D. Wilson, 2–44, research assistant; P. C. Grosse, 10–44, assistant; E. W. Keller, 10–44, assistant; B. H. Ciscel, research assistant; M. W. Essigmann, instructor; M. Loewenthal, research assistant; J. A. Wood, Jr., Assistant Professor of Electrical Engineering; and Patrick Youtz, research associate.

(*Continued on page 248*)

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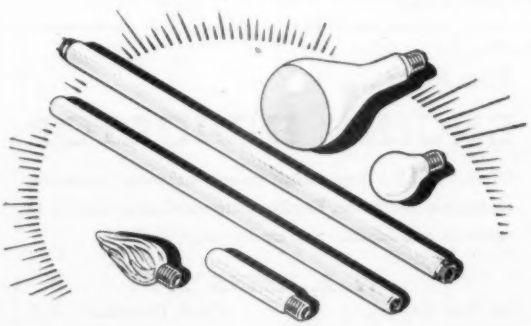

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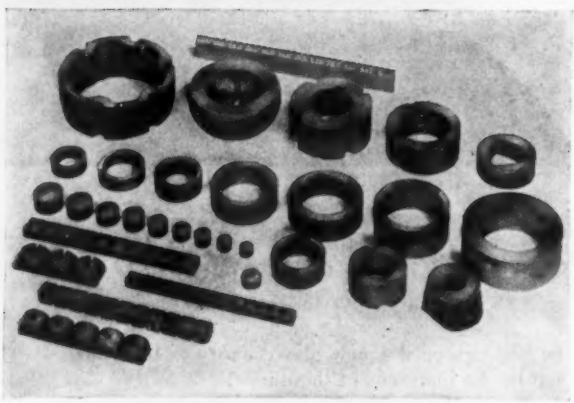

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TECHNOLOGY'S RADAR SCHOOL

(*Continued from page 246*)

reporting for duty as instructors. The constantly changing needs of the services required considerable rotation of officer instructors. The number of civilian instructors was kept as high as possible in order to promote continuity of instructional policies and to meet the expressed desires of the Army and Navy to minimize the number of officers required for teaching.

The administrative and teaching organizations of the school were modified from time to time as circumstances required. From the outset, however, the responsibilities for organizing and conducting the courses of instruction and for general operation of the school rested with a civilian director who was appointed by Dean Moreland. The senior naval officer at the Institute was in charge of all naval personnel and property assigned to the school. After April 24, 1942, the commanding officer of the Army Electronics Training Center (Harvard and M.I.T.) was in charge of all Army personnel and property at the school. Later, when the problems of naval administration had greatly increased, an officer in charge was assigned to the school.

W. L. Barrow, '29, Associate Professor of Electrical Communications, was director of the Radar School from June, 1941, until September, 1943. Professor C. E. Tucker, '18, has been director since that time. Others who served in the school administration are: W. H. Radford, '32, Associate Professor of Electrical Communications, as director in charge of instruction; H. J. Zimmermann, '42, as assistant director in charge of Army courses; J. A. Wood, Jr., Assistant Professor of Electrical Engineering, as assistant director in charge of Navy laboratories; S. K. Haynes as assistant director in charge of Navy lectures; M. S. McIlroy, '41, Assistant Professor of Electrical Engineering, as assistant director in charge of power and student records; and P. D. Appel, '22, as assistant director in charge of security and personnel. Commander J. L. Hornung has been officer in charge for the Navy since May, 1944.

In addition to the large teaching and administrative staff, many other workers were required for operation of the school. The stringent security regulations required the school to function entirely within continuously guarded areas. It was required to operate as a self-contained unit and therefore needed its own guard force, secretarial staff, print shop, photographic service, schedules and records office, maintenance shops, purchasing department, and first-aid facilities. At the peak of ac-

(*Concluded on page 250*)

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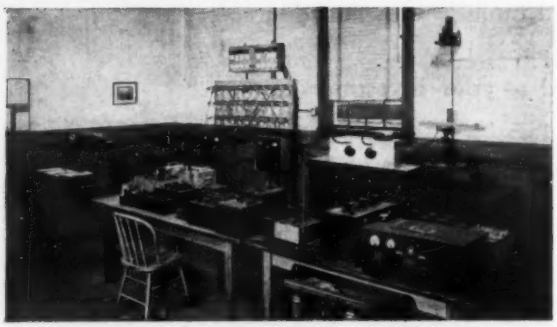

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TECHNOLOGY'S RADAR SCHOOL

(*Concluded from page 248*)

tivity, in the early summer of 1945, the service staff numbered 152 and included 36 guards, 25 janitors, 10 technicians, 32 secretaries, 20 print-shop clerks, 7 draftsmen, 1 lithographer, 1 nurse, and 20 enlisted personnel, including technicians, yeomen, storekeepers, and pharmacist's mates.

During the first two years of operation, substantially all expenses of the school were borne by the United States Office of Education under the national engineering war training program. After July 1, 1943, the school operated under government contracts, with the Army and Navy sharing operating costs in proportion to the number of students sponsored by each branch. The Army and Navy furnished all of the radar sets and much of the laboratory test equipment. The Navy also supplied all materials and labor for the installation of their equipment. While there was no official connection between the Radiation Laboratory and the Radar School, the laboratory assisted the school greatly, especially during the early years of operation, by lending prototype components of microwave radar systems and other apparatus and by furnishing essential technical information.

Many of the students at the Radar School expressed interest in postwar graduate study in the field of applied electronics, and it appears likely that a fair number will be admitted to the Institute for postwar study. The Institute has announced that it will grant a maximum of 24 "B" units of credit to any student who satisfactorily completed one of the regular three-, four-, or four-and-one-half-month courses at the Radar School.

The school is now being converted for postwar use and, starting with the 1946 spring term, will operate as a facility of the Department of Electrical Engineering. There will be laboratories and classrooms on the roof, 14th, and 12th floors of the Harbor Building and in Building 18 at the Institute. The school will continue under a Navy contract and initially will offer nine different electrical engineering subjects dealing with principles and applications of radio, radar, and sonar. All of these subjects will be classified and will be open only to officers and civilians designated by the Bureau of Naval Personnel. Most of these subjects are included in a new five-term curriculum in naval electronics which the Department of Electrical Engineering has arranged at the request of the Navy. This course leads to the degree of bachelor of science in electrical engineering and will be taken by selected graduates of the various Naval R.O.T.C. units. Some of the subjects offered at the Radar School will also be taken by officer graduate students from the Navy Postgraduate School and the Army Air Forces.

Naturally the Army and Navy officers as well as the civilians who served on the staff of the Radar School are proud of their part in the training of technical personnel during the war. They are equally proud that the Radar School has been selected to continue the higher level portions of its program in the era of peace. Probably no other act so aptly symbolizes the important role which radio, radar, and sonar are destined to play in this country's future as does the establishment of an educational center in which a nucleus of selected men will become trained in the instrumentalities for safeguarding this nation's security.

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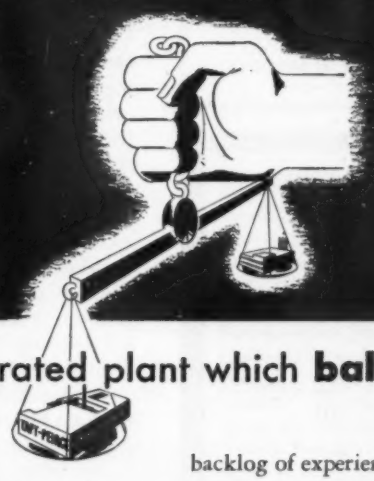

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THE AGE OF THE EARTH

(*Concluded from page 226*)

is plotted a qualitative curve of the history of volcanic activity and of earth heat. In the beginning, while the earth was gaseous, all earth was one vast volcano. During the liquid phase, the earth was one vast lava flow, and when the early crust formed, the earth had more and bigger volcanoes than ever since. So we must draw a curve of volcanism through the ages — an ever-flattening curve, as shown in Fig. 3 — for as the earth's crust thickened, volcanic activity diminished. But through all the 1,500,000,000 years of legible record we see no evidence that the earth's volcanic activity had lessened. The oldest lavas we can find are not bigger than those of the Age of Mammals. Even the Ice Age, wholly within the human period, saw the building and eruption of volcanoes that compare with any of which the earth has record. Indeed, all the active volcanoes of today are remnants, most of them dwarfed and dying, of the truly great volcanic action which culminated during the Ice Age.

As we try to peep through the curtain that hides the unrecorded era, our last glimpse of the oldest recorded volcanic action tells us that the earth was in much the same state then as now, and we may infer that much the same habits of volcanism had continued for a long time before the granite curtain closed.

Thus we recognize only two chapters of earth history, a hot-earth chapter and a cool-wet-earth chapter. Now if I try to figure out the true age of the earth, I begin with the excellent work of the chemists and physicists who measure the age of the oldest granites and give me a primary figure of 1,500,000,000 years, which I prophesy they will increase voluntarily in the near future. All this time lies wholly within the cool-wet chapter, and at that distant date, life was already old. Next must be added the unrecorded half of the cool-wet chapter, the duration of which is conservatively another billion years. Then must be added the wholly uncertain, but surely long, hot-earth chapter. The only estimates which mathematical astronomers have made of this chapter are unacceptable, not because their figures are at fault but because they cannot obtain the needed facts.

We conclude that the earth's history must be composed of three phases: the recent 1,500,000,000 years when the earth was in essentially its present form; a conjecturable billion years when the earth was in a transition from liquid to solid state; and a long era in which the earth was gaseous. The formula is indefinite, indeed, but the earth's age must approach 3,000,000,000 years. Although the figure is a guess, the order of magnitude is dictated by a vast array of significant facts and is likely to be too low rather than too high.

THE TREND OF AFFAIRS

(*Continued from page 222*)

mainly as an observing and experimental station and secondarily as a refuelling station for spaceships, and he wanted to place it as low as possible. It was to be just high enough so that it would not encounter atmospheric friction, and he named 1,000 kilometers as a figure.

(*Concluded on page 254*)

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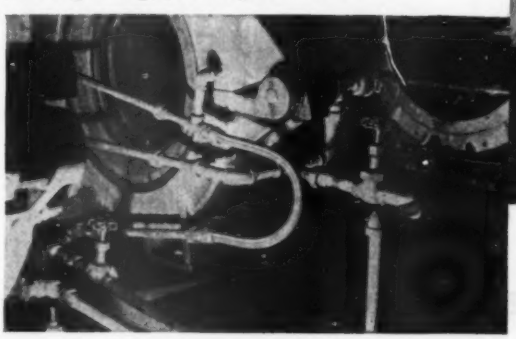

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THE TREND OF AFFAIRS

(Concluded from page 252)

A little later an Austrian engineer, Captain Potocnik, writing under the pen name of Wilhelm Noordung, advanced much more definite plans. His main objection to Oberth's placement was that a station only 1,000 kilometers from the surface would move rapidly with respect to the surface. Noordung calculated the distance so that the station would seem to be fixed above the earth's surface at about 26,300 miles. In reply to inconsistencies in Noordung's work, Count von Pirquet then evolved plans for two stations revolving at 470 and 3,100 miles from the surface, respectively, and connected by a so-called transit station traveling a more elliptical orbit, which was supposed to touch the other two. Since all this material was available in print,[1] it is hard to see how anybody could conceive of the space station as a great novelty which had to be dug up from secret German archives.

[1] Willy Ley, *Rockets* (New York: The Viking Press, 1944; 3d printing, 1945) pp. 220–247. (Contains a discussion of the work of Count von Pirquet which appeared originally in *Die Rakete*, the monthly journal of the German Rocket Society.

Hermann Noordung: *Das Problem der Befahrung des Weltraums* (Berlin, 1929). (Virtually the whole book is devoted to a discussion of the station in space.)

Hermann Oberth: *Die Rakete zu den Planetenräumen* (Munich, 1925, 2d edition), pp. 84–89.

Hermann Oberth, *Wege zur Raumschiffahrt* (Munich, 1929, 3d edition of preceding), pp. 350–371. (This book is now available as a photolithogravure reprint, Edwards Brothers, Inc., Ann Arbor, 1945.)

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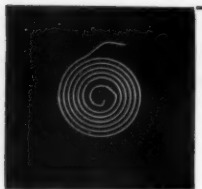

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TECHNOLOGY AND MEDICINE

(*Continued from page 234*)

heat. But direct current, direct-current pulses, and low frequencies are used in medicine. Recent research in shock therapy and also in the promising field of electronarcosis demonstrates the possibility of using electrical power of low frequency and various wave forms for specific purposes.

Among the great number of physical agents which are actually or potentially important in medicine, that of climatological environment is very interesting but may be rather problematic in its influence. Different authors report that some diseases, like arthritis and rheumatism, and certain psychological and physiological conditions depend upon the weather. Many people are affected by a change of atmospheric conditions, as, for instance, the arrival of a thunderstorm or a snowstorm, and such effects can be very pronounced, depending upon the geographic location. Since temperature, humidity, and barometric pressure do not appear to be involved in this effect, it has been claimed that the electrical condition of the atmosphere is the important factor. Russian workers report interesting progress in this field, but it seems that additional research is needed to reach definite conclusions. Medically important discoveries may result from further work in this field.

It has been said that physical therapy is a purely psychological treatment. Considering the decisive importance of psychology in medicine, no other statement could be of higher praise to physical therapy. The important question is only whether the effect of treatment with physical agents acts first in the imagination of the patient and from there acts upon his body or whether a physical or chemical change in the organism can be proven to be a direct consequence of the physical agent. We know today that both effects exist, but we do not know enough about the individual factors and how they interact. Fortunately, the physical and biophysical part of this complicated process is accessible to experimentation and exact measurement, and we may expect much progress from research in this field.

Education

In the future, the complexity of the physical phenomena involved in scientifically oriented investigations in physical medicine will require the services of trained physicists. Many hospitals have already recognized this fact and have added physicists to their staffs. Some have installed biophysical laboratories, analogous to the biochemical laboratories, which have long since proved their value. The tasks of a physicist in such a position are numerous. Besides his own research, often in collaboration with his medical colleagues, he works out plans for treatment in special cases (e.g., deep therapy); he develops physical methods for special diagnostic and therapeutic applications; he keeps the medical staff informed about progress in physical research; he teaches (particularly in medical schools) advanced and specialized courses; and he advises the medical research workers whenever they need physical methods and instruments in their own research. Inquiries for such physicists have already been received from hospitals, and the Institute has in operation

(*Concluded on page 258*)

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TECHNOLOGY AND MEDICINE

(Concluded from page 256)

plans for the training of physicists for the medical field. The training of physicists and engineers in this field will also be of interest to a number of industries, in particular those concerned with medical instrumentation. The anticipated expansion of this branch will require specialists, trained engineers, physicists, and biologists to an extent which perhaps may be comparable to the man-power requirements of the chemical pharmaceutical industries.

To establish an efficient liaison between physics and medicine it is not merely sufficient for the physicist to know more about medicine and biology. It is also necessary for the physician to apply the physical way of thinking to these problems and to acquire some knowledge of the available physical technological methods. The writer has repeatedly found that the physician, thinking in biological rather than physical terms, does not always appreciate the necessity of an objective physical dosimetric measurement. In short-wave diathermy, for instance, the subjective feeling of heat is frequently used as a criterion for dosage of the treatment and has been defended as "biological dosimetry," which was considered superior to "mechanistic physical dosimetry." It is obvious that such a biological dosimetry contains two unknown variables: the physical field intensity and the physiological sensitivity of the patient. Two treatments on patients of different sensitivities can give entirely different results, although both patients indicate the same biological dose. A better training of the physician in physics (either premedical or postgraduate) and an additional training in instrumentation for the specialist in physical medicine are necessary not only for the physical quantitative approach but also for a successful collaboration between physics and medicine.

The need for such a training has been recognized by the Baruch committee on physical medicine which has recently granted funds for the equipment of a physical medical laboratory to teach physicians the physical technological methods which are or can be applied in medicine and to develop and investigate such methods and instruments as may be most promising. This project is already in operation, but at the present time only a very limited number of applicants can be trained. The program offers a great opportunity for an intensive collaboration of physician and physicist from which may be expected new and better applications of physics and technology in medicine.

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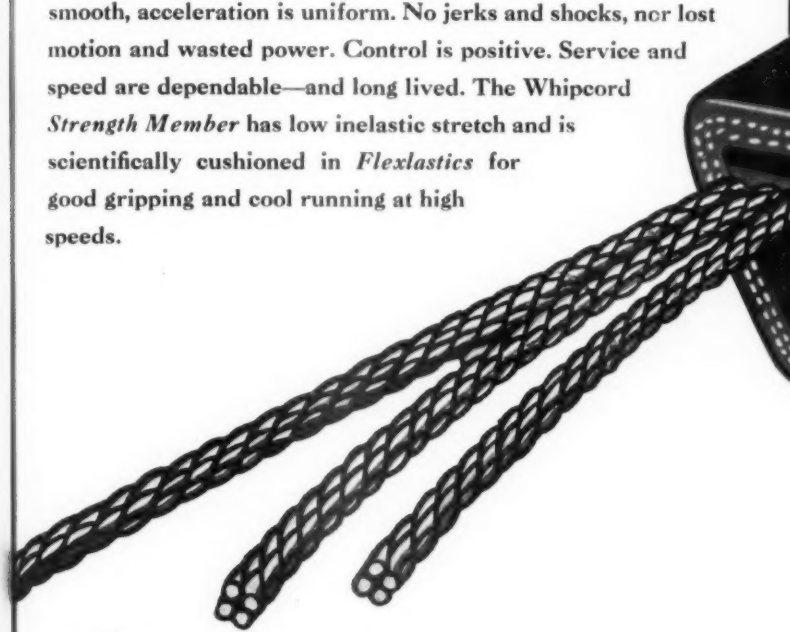

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